ENVIRONMENTAL IMPACT ASSESSMENT

PETROJAM REFINERY UPGRADE PROJECT

Report Submitted to:

Petrojam Limited

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GLOSSARY

Abbreviation	**Description**
ACGIH	American Conference of Government Industrial Hygienists
APHA	American Public Health Association
API	American Petroleum Institute
API	American Petroleum Institute
API	American Petroleum Institute
ARB	Air Resources Board
asl	Above sea level
AWWA	American Water Works Association
b/sd	barrels per stream day
bbl	Barrel of oil
bgl	Below ground level
BOD	Biochemical Oxygen Demand
bpd	Barrels per day
CCCL	Caribbean Cement Company Ltd
CCRU	Continuous Catalytic Reforming Unit
Cd	Cadmium
CDCs	Community development committees
CMC	Criteria Maximum Concentrations
COD	Chemical Oxygen Demand
Cr	Chromium
CRU	Catalytic Reforming Unit
DDPH	Dissolved/Dispersed Petroleum Hydrocarbons
DO	Dissolved Oxygen
ECD	Environmental Control Division
ECD	Environmental Health Division
EIA	Environmental Impact Assessment
FCCU	Fluid Catalytic Cracking Unit
GC/MSD	Gas chromatography/mass spectrometry
GDP	Gross domestic product
gpm	Gallons per minute
ha	Hectares
HCDC	Hope for Children Development Corporation
HiVol	High volume
IDFC	Intensity-Duration-Frequency curves
ISBL	Inside the Battery Limit
ISPS	International Ship and Port Security Code Plan
JET	Jamaica Environment Trust
JNAAQS	Jamaican National Ambient Air Quality Standard

Abbreviation	Description
JPPC	Jamaica Private Power Company
JPS	Jamaica Public Service Company Ltd.
JSLC	Jamaica Survey of Living Conditions
KMA	Kingston Metropolitan Area
KSA	Kingston and St. Andrew
KSAC	Kingston and St. Andrew Corporation
kt	Knot
LPG	Liquefied petroleum gas
MDEA	Methyl Diethanol Amine
MMBTU	Million British Thermal Units
MPN	Most Probable Number
MTBE	Methytertiarybutylether
NHT	Naphtha Hydrotreating
NMIA	Norman Manley International Airport
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NSWMA	National Solid Waste Authority
NWC	National Water Commission
OEHHA	Office of Environmental Health Hazard Assessment
OSBL	Outside the Battery Limit
PAP	Priority Air Pollutant
PCJ	Petroleum Corporation of Jamaica
PIOJ	Planning Institute of Jamaica
PM_{10}	Particulate Matter with diameter less than 10 micrometres
PSA	Pressure swing absorption
RfC	Reference Concentration (RfC) - An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer health effects during a lifetime. The inhalation reference concentration is for continuous inhalation exposures and is appropriately expressed in units of mg/m3 or ppm.
RfD	Reference Dose - An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure of the human population to a potential hazard that is likely to be without risk of deleterious effects during a lifetime. The RfD is operationally derived from the no-observed-adverse-effect level (NOAEL-from animal and human studies) by a consistent application of uncertainty factors that reflect various types of data used to estimate RfDs and an additional modifying factor, which is based on a professional judgment of the entire database on the chemical. The RfDs are not applicable to non-threshold effects such as cancer.
RO	Reverse Osmosis

Abbreviation	Description
RTBS	Rose Town Benevolent Society
RUP	Refinery upgrade project
SDC	Social Development Commission
SIA	socioeconomic impact assessment
SMR	Steam methane reforming
SO_2	Sulphur Dioxide
SPAW	Specially Protected Areas and Wildlife
SRU	Sulphur Recovery Unit
TDS	Total dissolved Solids
TG CDC	Tivoli Gardens CDC
TGTU	Tail Gas Treating Unit
TLV	Threshold Limit Values
TOR	Terms of Reference
TSP	Total Suspended Particulate matter
TSS	Suspended Solids
TSS	Total Suspended Solids
UDC	Urban Development Corporation
UWI	University of the West Indies
VOC	Volatile Organic Compound
WRA	Water Resources Authority

Executive Summary

Petrojam Limited proposes to upgrade its refinery located at 96 Marcus Garvey Drive in Kingston, Jamaica. The upgrade would expand the capacity of the refinery from 35,000 barrels per day (bpd) to 50,000 bpd and will entail upgrading some existing processing units and adding new processing and waste treatment units. The upgrade will allow the production of higher value refined petroleum products and better treatment of effluents from the refinery.

The refinery upgrade project (RUP) is of national importance, as it is expected to achieve a number of technical and national objectives including:

- Reducing the importation of finished petroleum products;
- Re-aligning the refinery's process configuration and capacity to match product yields with market demand;
- Production of environmentally friendly petroleum products (low sulphur diesel and gasoline);
- Assuring continued ability to supply petroleum products at least cost, by increasing its profitability through use of cheaper, heavier crude oils and
- Production of proportionately higher valued products from the crude oil raw material.

The existing units that will be upgraded are:

- Crude Distillation Unit
- Gas Recovery Unit
- Kerosene Hydrotreater

The main new process units that will be added are:

- Distillate Hydrotreater
- Naphtha Hydrotreater
- Continuous Catalyst Regeneration Platformer Unit
- Vacuum Distillation Unit
- Delayed Coking Unit

The new effluent treatment units are:

- Sour Water Stripper
- Amine Absorber
- Sulphur Recovery Unit
- Tail Gas Treatment Unit
- Waste Water Treatment Plant (includes upgrading the existing wastewater plant)

The National Environment and Planning Agency (NEPA) determined that the refinery upgrade project (RUP) will require an EIA, the Terms of Reference (TOR) for which (see Appendix 1) were finalised after consultation with and input by interested stakeholders. This EIA report addresses all of the items and aspects specified in the TOR. The EIA also conforms to the Equator Principles and the environmental, social standards of the International Financial Corporation (IFC), an institution of the World Bank Group that is responsible for transactions with the private sector.

Study Area

The various aspects of the EIA have potential impacts in areas that vary in size depending on the nature of the aspect. The various aspects and the study areas (ordered in increasing impact area) are as follows:

Occupational	On site
Marine ecology	200 m off shore the site inside Kingston Harbour
Water quality	
Marine	200 m off shore and inside Kingston Harbour
Wastewater	On-site and 50 m offshore (outfall)
Socio-economic	Within a 3km radius surrounding the site
Heritage sites	Within a 0.5 km radius surrounding the site
Geology	Onsite
Hydrology	Within a 2 km radius surrounding the site
Air quality & Human Health Effects	See Figure 1

The air quality study area (see entire Figure 1) is the largest because of the potential for the dispersion of airborne emissions from the facility. The general location of the refinery is shown in Figure 1.

Project Alternatives

The proposed project was selected from a number of alternatives. The three alternatives considered for the EIA were the do nothing (no upgrade), a terminalling option and the proposed RUP. The main features of these alternatives are summarised in Table 1.

Based on the economic viability (net present value) of the three options the Terminalling option is least attractive and the selected refinery upgrade option is the most attractive (See Table 1).

Public Consultation

Public consultation entailed an initial public meeting at which the proposed Terms of Reference for the EIA were presented and attendees provided valuable feedback. Additional meetings were held with representatives from four communities (Tivoli, Greenwich Town, Rose Town and Whitfield Town) at which formal presentations describing the project were made. Consultation with stakeholders took place as a component of the social impact assessment. Input was solicited from businesses in the Marcus Garvey Drive area, NGOs and from community leaders.

A second public meeting will be held to present the findings of the EIA.

Figure 1 Map of West Kingston - Jamaica, showing the Location of the Petrojam Limited Refinery Site

Table 1 Comparison of Project Alternatives

Factor Considered	Do Nothing	Terminalling	Proposed Refinery Upgrade Project
Ability to meet local demand	Refinery capacity cannot meet local demand for gasoline and diesel. Continued import of some finished products	Demand for all products met entirely by imports	Demand met by upgrade Imports of finished products would be eliminated
Ability to meet fuel quality (ultra low sulphur diesel & low sulphur gasoline) needs	Could not produce low sulphur diesel	Demand met entirely by imports	Will produce required ultra low sulphur diesel & low sulphur gasoline
Importation	Requires additional finished product importation	Demand met entirely by imports	Import of additional crude
Low (2.2%) sulphur heavy fuel oil	Requires continued importation	Demand met entirely by imports	Requires continued importation of 2.2% HFO
Crude quality	Requires higher quality crude	Not applicable	Allows lower quality crude to be used
Introduction of new products and by-products	None	Not applicable	Production of Pet coke for use in adjacent power generation station Export of intermediate products (vacuum gas oil (VGO) Production of sulphur for local use and for export
Employment	No change	Fewer employees (~30% of current work force)	Additional employment during construction and operation after the upgrade
Synergies	No change	Lost taxes and loss of ~US $10 million to economy	Pet coke used to generate electricity at an adjacent JPS generating station; sulphur by products used locally and

Factor Considered	Do Nothing	Terminalling	Proposed Refinery Upgrade Project
			excess exported
Capital cost	None	US $1 million for decommissioning	US $758 million as at November 2008[1]
Economic viability	Would incur decommissioning costs	Lower operational costs Elimination of current government-to-government crude oil agreements	Increased profit margin
Net Present values (@12%)	US $126.5 million	US $52.2 million	US $184.8 million

[1] As indicated by Front Engineering Design Contractors, SNC Lavalin Inc.

Description of the Existing Environment – Baseline Studies

Baseline studies were conducted to characterise the physical, biological, and sociological/socioeconomic features that are influenced by the existing refinery operations. The aspects covered in each of the three areas are as follows:

Physical	Geology, soils, hydrology, water resources, climate, air quality, occupational exposure, emergency response plans, waste management,
Biological	Terrestrial, avifauna, marine
Socioeconomic	Demography, infrastructure & services, housing, amenities, community fabric/cohesion, economic activities, public perception, land use, macroeconomic

Physical

The refinery site is located on reclaimed land whose geology is classified as Alluvium Aquifer. The site is suitable only for industrial use. The subsurface is made up of material classified as engineering fill. Because of this the site is susceptible to liquefaction[2] and ground failure during earthquakes.

Geology & hydrology

The site is located in the Liguanea alluvium aquifer. Groundwater in the aquifer is not suitable for drinking because of contamination by nitrate from sewage. Except for the coastal areas of the aquifer, groundwater is suitable for irrigation and industrial purposes. Near the coast groundwater is affected by saline intrusion and must be treated before it can be used for most industrial purposes.

The abstraction rates of water from wells on the Petrojam site are within the limits specified in the licences for the wells issued by the Water Resources Authority and do not affect nearby (within ~1 km of the site) wells.

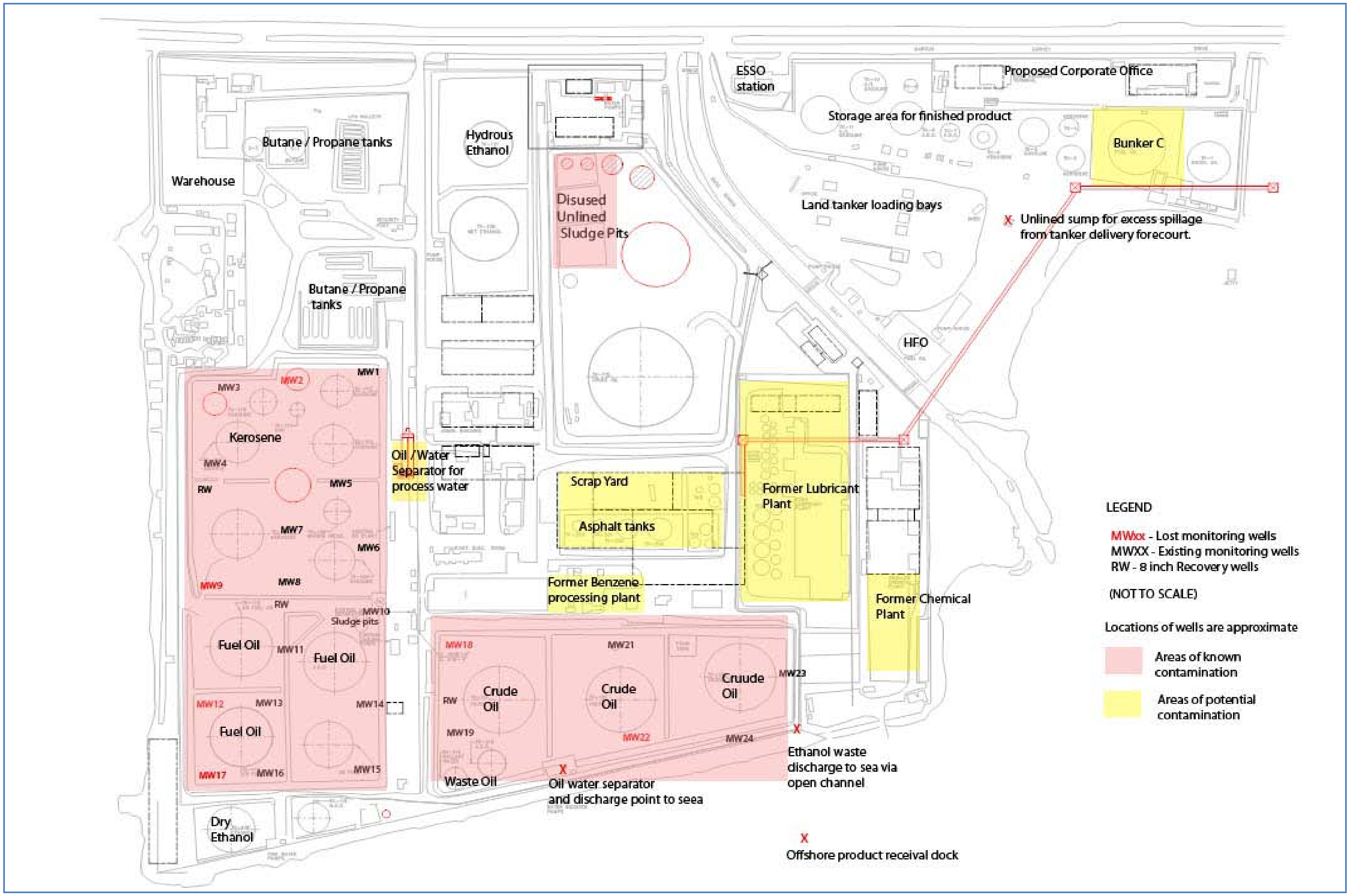
There is an ongoing program to assess the extent of previous leakage of petroleum products from storage tanks. Boreholes have been drilled to monitor ground water quality and recovery wells have been drilled to recover some of the leaked hydrocarbons. The extents of the known and potential contaminated areas (see Figure 2) have been determined and the remedial program is ongoing.

Oil Spills

There have been no reported ship oil spill incidents in Kingston Harbour since 2003. There have been minor spills (associated with coupling of hoses at the Petrojam marine dock) but their small amounts did not warrant any cleanup. Cleanup was required however as a result of a power failure incident during hurricane Ivan.

[2] Soil liquefaction occurs when soil loses its strength (shear resistance) for example because of shaking during an earthquake: this causes the soil to flow in a manner resembling a liquid.

Figure 2 Locations of Known and Potential Hydrocarbon Contamination to Soil and Water (Not To Scale)



Drainage and Storm Surge Assessment

The site is fully developed with extensive hard surface areas and consequently the run off potential during rainfall events is high. The site is well served by a system of drains and is flanked on the east by the Shoemaker Gully. No flooding of the site or overflowing of the Shoemaker Gully has been reported.

The storm surge analysis estimated highest wave heights for the worst case events that would occur once in 25 years and once in 100 years. The Petrojam Refinery site is sheltered from the Caribbean Sea by the Palisadoes. The presence of cays outside the harbour and the shallow areas inside the harbour serve to mitigate the impact of storm surges from the open sea (southwest). The storm surge analysis indicates that the highest waves at the eastern section of the refinery site (1.49 m for the 1-in-25 years and 1.73 m for the 1-in-100 years) would arise from the east-south-east as a result of waves generated inside the harbour. Storm surge impacts are therefore of minor concern.

Ambient Water Quality

Existing (baseline) water quality in the harbour was determined from monitoring data at four locations – three in the vicinity of the refinery's trade effluent outfalls and at a background site outside the harbour. The monitoring data were compared with the US EPA ambient standards for marine waters since there are no equivalent NRCA or NEPA standards. At all four stations, fecal coliform levels were below but nitrate and phosphate levels were above the corresponding standards. At the station east of the Petrojam outfall BOD and TSS levels were above and at the station near the API separator outfall the DO and BOD levels were above the corresponding standards.

Climate and Air Quality

The main climatic features that contribute to potential environmental impacts from the refinery are the rainfall patterns, the wind regime and to a lesser extent temperature. The rainfall patterns were considered in the assessment of drainage. Similarly, hurricane climatology which is a specialised subset of the overall climatology was used in the storm surge analysis. Wind and temperature conditions are important in determining the dispersion of pollutants once released to the air.

Climatology

Jamaica is under the influence of prevailing north-east trade winds. For locations on the south coast of Jamaica (such as the Petrojam site) the mountains that lie along an east-west axis of the island deflect the north-east trade winds (and provide an easterly component) and together with sea breeze effects (north and south components) result in predominant winds from the east-south-east and south-east.

The temperature regime for period 1990 to 2001 ranged from a minimum of 22.6 ^{o}C to a maximum of 32.8 ^{o}C; the mean daily temperature over the period was 28.2 ^{o}C.

Air Pollutant Sources

The Annual emissions from major air pollution point sources in the Kingston airshed are summarised in Table 2. The existing Petrojam sources account for about 15.6% of sulphur dioxide (SO_2) emissions, 1.2% of nitrogen oxides (NOx) emissions, 12.7% of particulate matter (PM) emissions, 0.2% of carbon monoxide (CO) emissions and 0.2% of VOC emissions from major point sources. Other sources in the airshed are mobile sources (on-road vehicles, aircraft emissions during landings and take-offs) which emit mainly NOx, CO and non-methane volatile organic compounds (NMVOC) but much less SO_2 and smaller point and fugitive sources with emissions of SO_2 and PM. The NOx and CO emissions from the Petrojam refinery account for a small percentage of these emissions in the airshed and hence will have little impact on the ambient levels of CO and NOx. Petrojam's SO_2, PM and VOC emissions although relatively small have the potential to affect ambient levels of these pollutants at least in the vicinity of the refinery. It is for these reasons that ambient measurements of VOCs, PM and SO_2 were measured at sites near the refinery during the EIA and available historical ambient air quality data in the airshed were reviewed.

Existing Air Quality

In connection with their air quality licence applications, Petrojam and JPS – because of their close proximity to each other, proposed to conduct joint ambient air quality monitoring for SO_2, NOx and particulate matter with diameters less than 10 um (PM_{10}). It was anticipated that the equipment ordered for that program would have been available for the EIA but unforeseen delays prevented the establishment of the three monitoring stations in time for data from those stations to be included in the EIA.

Instead, total suspended particulate matter TSP was measured at two locations using a high volume (Hi-Vol) sampler and a Mini-Vol sampler (MVS). Passive sampling methods were used at six stations to measure SO_2 and NO_2. One of the six stations was at Kelly Pen near Old Harbour where continuous SO_2 and NOx analyzers are available so that the measurements from the passive samplers could be compared with those from the continuous analyzers. The comparisons will not allow any indication of hourly levels (since the exposure period for the passive samplers is ~10 days) but will provide some measure of ambient air quality over a 10 day and longer periods.

TSP levels from the Hi-Vol sampler at the Petrojam Boat House (BH) during the sampling period were in the range 4 to 91 $\mu g\ m^{-3}$ with an average of 47 $\mu g\ m^{-3}$. At the loading rack site the measurements made with the MVS sampler ranged from 12 to 143 $\mu g\ m^{-3}$ with an average of 68 $\mu g\ m^{-3}$. All values were well below the NRCA ambient air quality 24 hr standard for TSP (160 $\mu g\ m^{-3}$). The BH site also had a MVS sampler so that comparisons could be made with the Hi-Vol sampler (which is approved for use by NEPA) since the MVS sampler is not an approved instrument. NEPA allows use of such instruments once comparisons are available with approved instruments. The comparison between the two samplers was poor but the MVS on average showed higher measurements by a factor of 2.6. On this basis, although subject to

Table 2 Kingston Airshed Point Source Emissions

Description	Annual Emission Rates (tonne/y)				
	SO_2	NOx	PM	CO	VOC
Petrojam Flare	8.94	0.75	0.00	0.04	0.38
Petrojam Pipestill heater	1300	150	93.1	12.93	0.26
Petrojam Powerformer Feed preheater F-2/3/4	395	33.2	0.517	6.03	0.48
Petrojam Vacuum furnace	71.5	4.15	0.089	1.04	0.08
Petrojam Nebraska (Oil)	1067	2.54	70.5	11.33	0.22
Petrojam New Cleaver Brooks Boiler	485	1.15	32.0	5.14	0.10
Petrojam Hurst Boiler	242	0.576	16.0	2.57	0.05
D&G Boiler Stack East	278	27.8	17.3	2.96	0.06
D&G Boiler Stack West	194	19.4	15.5	2.06	0.04
D&G Boiler Stack	194	19.4	15.5	2.06	0.04
JPPC Engine 1	1039	4049	285	872	331
JPPC Engine 2	1039	4049	285	872	331
CCC Kiln 4 Dry 1300 tons/d	124	796	59.8	225	0.00
CCC Kiln 3 Wet 700 tons/d	1199	1082	67.2	1.70	0.00
JPS-Rockfort	2864	1581	79.5	3769	198
JPS-Rockfort	3329	1337	82.3	3769	198
JPS-Hunts Bay B6	7132	741	281	6409	0.54
JPS Hunts Bay GT (GT10)	517	1088	95.1	42.6	0.163
Jamaica Ethanol Processing Ltd.	427	42.6	20.4	4.53	0.06
Caribbean Products Company Ltd.	223	0.529	14.7	2.36	0.05
JPS Hunts Bay GT (A5)	781	720	63.0	25.5	0.00
Caribbean Cement Company Clinker cooler 3	0.00	0	19.9	0.00	0.00
Caribbean Cement Company Clinker cooler 4	0.00	0.00	31.3	0.00	0.00
D&G Grain handling	0.00	0.00	20.4	0.00	0.00
Total	**22,910**	**15,744**	**1,665**	**16,038**	1,060
Petrojam	3,570	192	212	39	1.57
Petrojam % of Total Point Sources	15.6	1.2	12.7	0.24	0.15

considerable uncertainty, the Loading Rack MVS measurements (which were all below the NRCA standard) are likely to be even lower than that reported by the Hi-Vol sampler.

Volatile Organic Compound (VOC) Measurements

VOCs are released from storage tanks at the refinery as well as from fugitive sources (valves, flanges, drains etc) in various refinery processes. VOCs are also released from motor vehicles because of evaporation of fuel and from the tailpipe. Ambient levels of VOCs were measured at five locations using passive devices (3M badges) that were exposed (two at each site) for 24 ± 0.2 h. The exposed badges were analysed for individual compounds. The compounds include 13 aromatic and saturated hydrocarbons released from refinery operations and motor vehicles, two compounds released from vegetation and some consumer products and two chlorinated solvents one of which is used at the refinery and in dry cleaning. Some of these compounds are included in the Priority Air Pollutant (PAP) list specified in the Air Quality Regulations and for which there are ambient air guideline concentrations.

Benzene is the only compound whose measured concentrations are above the NRCA Guideline limit. The measured concentrations for the remaining compounds were lower (by factors ranging from 7 to 3300) than the corresponding limits[3].

The concentrations of tetrachloroethylene, trichloroethylene, 2,2-dimethylbutane, a-pinene, decane and d-Limonene showed no variation across the five monitoring sites hence indicating no nearby sources for these compounds. The highest concentrations of the other compounds (benzene, xylenes, toluene, n-pentane) were at the loading rack (LR) site which is located within 50 m of the loading rack where gasoline, kerosene, and diesel fuel are loaded on to tankers. These compounds are also expected to be emitted from traffic sources (evaporative and exhaust emissions) and because of this it is not feasible to distinguish between the exhaust and evaporative emissions from traffic and those from the refinery operations.

The second highest concentrations were at the Boat House (BH) site and the concentrations decreased as the distance downwind (towards the west) from the refinery increased. It is therefore clear that the refinery is a source for the VOCs. The potential impact of benzene was addressed in the health risk assessment.

Historical Ambient Air Quality Data

There are limited ambient air quality data available for the Kingston airshed. NEPA only reported monthly average SO_2 and NO_2 concentrations measured at Cross Roads for limited periods between April 2006 and 2007 although continuous analysers (three minute averages) were used to take measurements. The monthly average SO_2 concentrations which ranged from 30 to 37 $\mu g\ m^{-3}$ suggest that the annual mean SO_2 concentration would be well below the

[3] For compounds with no limits for a 24 h averaging period, the measured 24 h average values were extrapolated to an annual average which was then compared to the annual limit.

JNAAQS for the annual average SO_2 concentration (60 µg m^{-3}). The NEPA report indicated that the highest hourly average NO_2 concentration was 77 µg m^{-3} – which is well below the NRCA Guideline concentration of 400 µg m^{-3} for a 1-hour average.

TSP and PM_{10} concentrations measured by NEPA at three locations (NEPA Office at Cross Roads [XRDS], NEPA Laboratory at 191 Old Hope Road [OHR] and at Harbour View [HV]) were well below the 24 h JNAAQS. None of these sites is near the refinery.

NO_2 concentrations measured using passive monitors at up to 19 locations in the Kingston & St Andrew airshed at various times during 2001, 2004 and 2006 gave mean weekly averaged NO_2 concentrations ranging from 10 to 46 µg m^{-3}. The lowest weekly average NO_2 concentrations were at sites to the north of the study area (Chancery Hall, Norbrook Heights, and Constant Spring Golf Club). The highest measured NO_2 concentrations were at the Cross Roads, Half Way Tree and Matilda's Corner sites which were located near high traffic road intersections. The weekly average NO_2 concentrations at a site located on Marcus Garvey Drive between the Refinery and the JPS Hunts Bay station were in the range 20 to 39 µg m^{-3}.

Two-week average SO_2 concentrations made using the passive SO_2 monitors at up to six sites during April to July 2007 ranged from 7 to 42 µg m^{-3}. The highest values were measured at Camperdown High School which is located near to the power stations and a cement plant in the Rockfort area. None of the monitoring sites were located near the refinery.

Occupational Health

Noise

Eight sets of sound level measurements over entire work shifts were made at six locations near the refinery between September 4 and 23, 2008. The measurements were made twice at two locations (maintenance workshop and laboratory) since sound levels were expected to vary. Continuous equivalent A-weighted sound level (LA) measured at the main work stations ranged from a high of 93.4 dbA at the Process Unit to a quiet 48.1dbA in the lobby of the Administration building. Measurements at the Process Unit location had a level above the OSHA Action Level. The main source on the Process Unit as well as at the Smoke Shed was Furnace F-1. At the Smoke Shed and the Maintenance Workshop the noise levels approached but did not exceed the Action Level. Petrojam uses signs to advise workers of high noise level areas and requires the use of personal protective equipment (ear plugs or ear muffs) in high noise areas.

VOC Measurements

Passive devices were also deployed at seven (7) locations on the refinery site to measure VOC concentrations over a 12 hour shift. The concentrations of the individual compounds (the same set as used in the ambient measurements) were all below the NIOSH occupational standards (8 h time weighted average concentration) or Threshold Limit Values (TLV).

<u>Emergency Response Plans</u>

Petrojam has developed and documented a comprehensive Health, Safety, and Environmental Management (HSEM) program that includes emergency response plans. The program is based on Process Safety Management (PSM) and is based on voluntary compliance with the United States Occupational Health and Safety Administration (OSHA) regulations 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals. The OSHA regulations are more comprehensive and stringent than the applicable Jamaican legislation that governs Petrojam's operations.

The emergency response plans fall under the following headings:

Fire Emergency Plan

Oil Spill Response Plan

International Ship and Port Security Code Plan (ISPS) Plan

Evacuation Plan

Civil Unrest

Hurricane Preparedness and Response

Earthquake Response Plan

An integral part of the emergency response plans are protocols for notification of relevant national emergency agencies (Police, Fire Brigade, Ambulance, NEPA, Port Authority, Coast Guard) and communication with nearby residents and businesses. Petrojam has instituted a Community Outreach Committee and an outreach program that includes regular meetings with community members. However, it was noted at the initial EIA public meeting that there was need for improvement in the communication/warnings

<u>Waste Management</u>

Liquid Wastes

Two separate waste water streams are discharged from the refinery. Rejected water from the reverse osmosis treatment plant and blowdown water from a cooling tower are discharged into the storm water drain. The other stream comprises waste water from various processing units which is treated in an oil/water API separator before discharge to the harbour. Over the 1 year period ending April 2008, at both outfalls the levels for conductivity, total dissolved solids (TDS) and total suspended solids (TSS) were always below (100% compliance) the corresponding NRCA Trade Effluent Standards. For the other parameters, the compliance percentages with the standards at the storm drain outfall were 58% (Temperature), 51% (oil and grease), 68% (pH) and 10% (sulphide); at the API separator effluent the compliance percentages were 66% (Temperature), 41% (oil & grease), 98% (pH), and 37%(sulphide).

Processing Solid Waste

Solid waste from processing units (e.g., spent hydrofiner catalysts and chloride adsorbents) are placed in drums, held on site in a designated area and accumulated into batches until the size is suitable for shipment overseas to recycling companies. In the case of UOP R86 platforming catalyst, it is shipped to the vendor for recovery of metallic platinum. Used inert silica balls are stored on site in drums and incorporated in concrete mix used mainly in the bund walls of the tank farm.

Hydrocarbon sludge generated on site and from off-site sources is treated in the sludge reprocessing plant. Solids from this process are stored in drums and held on site in a designated area while hydrocarbon liquids are sent to crude tanks and oily water is sent to the API separator. Since there is no hazardous waste disposal site in Jamaica, hence Petrojam stores the waste onsite.

Domestic Solid Waste

Domestic wastes are sent to the municipal solid waste management site by a contracted garbage disposal service. All domestic sewage generated on the site is discharged to the National Water Commission (NWC) sewer.

Biological

Terrestrial

Since the refinery site has been a well developed industrial site for over 40 years biodiversity is very low and there are no rare or endemic plant (or other faunal) species on the site. Plant species on the site were catalogued.

Avifauna

During the site visit the few birds seen were engaged in foraging activities. The longstanding industrial nature of the site and the pollution of the harbour make the marine environment immediately offshore the facility unattractive for birds.

Marine

An assessment and classification of the relevant pelagic and benthic marine communities was made to determine the presence of ecologically or commercially important marine species.

Two dives were conducted along east-west transects parallel to the southern shore line of the Petrojam property. No benthic or mobile resources were noted during either transect swims. Few organisms (stingray, green sea urchin, bivalves and empty bivalve shells) were found and no fish were seen, presumably because of the turbid water. The substrates tended to change in composition from the muddy silt sampled on the west to the calcareous fragments sampled to the east. The presence of the mud was regarded as being the result of proximity to the Hunts Bay discharges, with increasing distances from this discharge (progressing eastward) resulting in less mud. Macro-algae were observed on any available hard surface.

Sociological/Socioeconomic

Demography

The population within 0.5 km of the Petrojam site was 8,891 while between 0.5 and 2 km from the site, the population was 75,456. Survey results conducted within the Socioeconomic Impact Assessment (SIA) study area showed that the average household size is 4 individuals with ranges from 1 to 11 persons per household. This average is consistent with that of the Social Development Commission (SDC) data. The average household size in the study area exceeds the national average of 3.3. The figure also represents an increase from the 2002 Parish average of 3.2. Eighty four percent (84%) of respondents to the SIA survey conducted for the EIA are the head of their households. Of these, 60% were males while 40% were females. The majority (76%) of the household heads were between the ages of 30 and 59, 17% were aged 18-29 years and 7% were over 60.

Infrastructure and Services

The modes of travel to work or school were taxis (40%), minibuses (23%), own private vehicles (9%) and public transportation (by the Jamaica Urban Transit Company (JUTC)) (24%). Survey respondents reported the distances travelled to work or school as follows: less than 1.6 km (51%), 1.6 to 8 km (33%), more than 8 km (14%) and varying distances (2%).

The SIA study area is served by 9 health centres and two hospitals (Kingston Public Hospital and Victoria Jubilee Hospital). One health facility is within 0.5 km of the Petrojam site. There are at least 83 schools serving the area of which 65% are basic and infant schools, 19% are Primary schools, 11% high schools and 5% vocational schools. The Ministry of Education's 2006/2007 Directory of Public Educational Institutions lists 1 Community College, 3 Teachers Colleges, a Multi-disciplinary and 2 Universities within Kingston Metropolitan Area (KMA). A skills training facility, Garmex which is operated by HEART Trust NTA is located close to the proposed project site across Marcus Garvey Drive.

Housing

Housing and land tenure data were available for only two of the 17 communities in the SIA study area. In these communities the percentages of persons who reportedly owned their homes were ~ 65% in one (Denham Town) and 9% in the other (Greenwich Town/Newport West). Twenty eight percent (28%) of Denham Town residents lived "free" while 4.4% rented. In contrast only 7.5% of Denham Town residents reported owning the land on which their homes are located and 2.5% leased. This implies that approximately 55% of residents may be squatting. In Greenwich Town/Newport West, 60% of residents reported renting their homes while 30% "captured" them and 10% own or lease their homes.

Land ownership ranged from 7.5% to 43% in selected communities. Other reported tenure types were rent, lease, family and capture. The SDC reported a total of 18 squatter settlements in four of the 17 communities within the SIA study area.

The SIA survey results for the types of construction materials used in housing in the SIA were block and steel 70%, wood 11% and the remaining 19% declined to respond. This is consistent with the 2006 JSLC figure for the KMA. The most popular materials for roofs were zinc (54.5%) and concrete (10%) and for fencing were zinc (24.5%) and block and steel (14.5%).

Amenities

Access to amenities (toilet facilities, piped water in dwellings, electricity, fuel for cooking and telephone, lighting and telephone) were deduced from data for the KMA derived in the Jamaica Survey of Living Conditions (JSLC), the SDC Community Profile and the most recent (2007) Jamaica Socioeconomic Survey published by the Planning Institute of Jamaica (PIOJ). In 2006, the percentages of households in the KMA with these amenities were: flushed toilet - 89.9%; pit latrines -8.6%; and cell phones – more than 50%. The main source of fuel for cooking was liquefied petroleum gas (LPG) and lighting was electricity. Collection of municipal waste is by the National Solid Waste Management Authority (NSWMA) 97% of households or by private contractor (3%).

Community Fabric Cohesion

Community fabric and cohesiveness is considered very strong within the communities in the study area although some communities have divisions within them and there is little or no interaction between communities. The SDC community profiles indicate that there are active community-based organizations (CBOs), non-government organizations (NGOs), sports clubs and church groups in most of the communities within the study area. There are also numerous social interventions geared at skills training, maintaining peace, homework programs and community development. The majority of the communities also have a community centre that is in fair to good condition.

Petrojam established a Community Outreach Committee which liaises with the Greenwich Town community representatives and Petrojam staff. The terms of reference include evaluating and recommending the most cost-effective community related projects; developing appropriate projects and initiatives to enhance the well being of the community; identifying specific projects such as adopt-a-school, home work program etc. and making recommendations for consideration by Petrojam Management. To date, one project was successfully completed, the community centre and basic school was upgraded in Greenwich Town. Additionally, there is an annual health fair at Petrojam that is open to all residents within the surrounding areas. Petrojam also provides two scholarships to high school students annually.

Residents of many communities perceive crime as being low to moderate. This is reflected in the proportion of them indicating that they felt safe. Residents expressed moderate to high fear in two communities namely, Maxfield Park and Greenwich Town/Newport West. There was fear of gangs and warfare including reprisal killings and drive by shootings. The community liaison officer at the Hunts Bay Police Station was contacted for an interview but unfortunately it was not possible to conduct the interview.

National heritage sites

The Jamaica National Heritage Trust indicated that there are no Historical Sites within the 0.5 km of the study site.

Economic

The entire southern portion of the area consists of an industrial and commercial corridor which includes the Petrojam Limited Refinery (study site), Kingston Wharves and associated shipping terminals, warehouses and offices of brokerage firms, the Jamaica Public Service (JPS) Hunts Bay Power Plant and the Greenwich Town Fishing village among others. Economic activities within the residential communities are mainly small enterprises – shops and bars.

The Greenwich Town Fishing Beach is located immediately west of the study site. A 2002 study indicated that there were an estimated 350 fisher folk operating from the fishing beach with 200 owning or controlling beach structures. At that time there were 218 structures on the beach, 72 of which were structures and gear sheds belonging to the Fisheries Division. The 146 privately owned structures included 60% of which were “lived in” and 16% were shops and stalls for vendors, some of which were actually lived in. The remaining 24% (35 structures) were reportedly not lived in but were net- or boat/tackle-related structures. The estimated catch for the week was 100,000 lbs of fish with 112 active boats.

During the SIA survey for this EIA, there were fewer structures on the beach than was observed in 2002. This was largely due to the destruction by Hurricanes Ivan in 2004. Approximately 80 structures were observed, 62 of which were concrete gear sheds. The remaining structures were wood and zinc structures that were lived-in, shops or equipment sheds.

Employment and Income

Seventy five percent (75%) of the 110 participants surveyed reported being employed. Of those employed, 46% were self-employed, 39% had full time jobs, 12% had part-time, while 4% had seasonal jobs or other employment. The main occupation types included construction workers, business owners, fisher folk, vendors, shopkeepers, teachers, pastors and trade workers (painters, mechanics, tailors and dressmakers). Fisher folk accounted for the largest occupation type interviewed as a result of their concentration at the Greenwich Town Fishing Beach.

Sixty five percent (65%) of survey respondents agreed to give income information. Of these 69% reported earning $3,000-$10,000 per week, 16% less than $3,000, 8% earned $10,0001 - $20,000, and 7% over $20,000. The survey findings are consistent with the SDC community profiles which identified high unemployment levels as a characteristic of the study area. The SDC survey reported 37% of household heads were unemployed. Among the youths (15-24), unemployment was reported at 40%. The high levels of unemployment may be related to the low skills level and educational attainment of the communities within the study area.

Public Perception

Public perception of the project was derived from interviews with members of various communities and with stakeholders (four community development committees, two NGOs, one business and the Kingston and St Andrew Corporation (KSAC). Requests for interviews with other business along Marcus Garvey Drive were unanswered.

The main positive comments from the communities were that the proposed development would be good for employment and training opportunities and would contribute to economic development in the area. They further commented that the opportunities should be made available in all communities within the area. Their main concerns were the possibility of the project not being implemented or if implemented that the people in the surrounding communities would not benefit. They were also concerned about the increased potential for exposure to hazards and the lack of emergency response plans that fully engaged the community.

The CDCs all felt that the upgrade project would have a positive impact on employment in nearby communities. Some were urging that appropriate training programs targeted at residents in these communities be put in place early in order to develop some of the skills needed at the refinery. Concerns were expressed about potential negative environmental and health impacts but felt that Petrojam and the EIA process would minimise such impacts.

For the sole business that responded (JPS) most survey respondents also felt that the project would have positive impacts on employment and on the adjacent communities. With regard to impacts on their company, respondents felt that the availability of lower cost fuel and the diversification of the fuels used for electricity generation would have national benefits (lower cost of imported fuel, lower electricity costs).

The survey completed by the Jamaica Environmental Trust (JET) - the sole non-government organisation NGO that completed the survey - noted that the availability of low sulphur fuels that the refinery will produce will be beneficial to the environment since it will help to improve air quality across Jamaica. They looked forward to “a thorough assessment of all pollution control alternatives that are available to Petrojam and a full, quantitative assessment of the air and water quality impacts of the facility before and after the upgrade”.

Land Use

The lands to the north and east of the refinery site have heavy industrial, light industrial, commercial and residential uses. The southern boundary of the site borders Kingston Harbour.

The Down Town Kingston area is to the east of the site while to the north are the communities of Whitfield Park and Delacree Pen. Immediately adjacent to the site is the Greenwich Town Fishing beach and further west is New Port West. Land use within these areas is varied. The western portions are mainly commercial with some residential and light and heavy industrial. Lands to the north are mainly residential communities with commercial and open spaces. Several schools, a cemetery and other government facilities are also located within this area.

The lands to the west are commercial, light industrial and an aerodrome. Some residential areas are also located within this area

Macroeconomic

The role that Petrojam plays in Jamaica's economic development is important because of the energy intensive bauxite and alumina industry, the increasing demand for fuel to generate electricity and for transportation. With minimal indigenous sources of fuel, Jamaica is heavily dependent on imported fuel to meet its energy demand. The rapid increase in oil prices in 2007 and 2008 lead to increased foreign exchange needed to purchase petroleum products. Although crude oil prices have declined since the peak in July 2008 the effects of the surge in oil prices remain and have been compounded by the global recession. The availability of stable, adequate and diversified energy supplies is desirable in order to minimise external influences such as fluctuations in prices or supplies.

Jamaica has been adversely impacted by several hurricanes over the past two decades and one of the predicted climate change impacts is an increase in the frequency and intensity of weather systems such as tropical storms and hurricanes which have inflicted billions of dollars in damages and losses especially to coastal areas. Of immediate concern is the need to continue putting in place measures that will reduce our vulnerability to hurricanes (and other natural disasters) and in the longer term to protect coastal assets and/or otherwise mitigate the longer term impacts of climate change. In response to climate change concerns, international conventions such as the Kyoto Protocol (to which Jamaica is a signatory) are attempting to secure voluntary commitments to reduce global greenhouse gas emissions from energy related and other activities.

Key policy initiatives have been the development of the Energy Sector Plan – a component of the *Draft Vision 2030 Jamaica - National Development Plan* and the *Green Paper: The Energy Sector Policy 2006 - 2020*. The policy objectives of the Green Paper include ensuring stable and adequate energy supplies, protecting the economy from energy price volatility and minimising the adverse environmental effects from the production, storage, transport and use of energy. The refinery upgrade project addresses and is consistent with these policy initiatives and in fact will help to implement them.

Policy, Legislative and Regulatory Regime

Responsibility for implementing and enforcing the instruments associated with the regime lies with several government entities (ministries, executive agencies) as mandated by various Acts, regulations and policies.

The National Environment and Planning Agency (NEPA) is the principal agency responsible for implementing the Natural Resources Conservation Authority Act and its regulations as well as the Beach Control Act and the Land Development and Utilization Act. NEPA also has responsibilities under The Town and Country Planning Act, the Watersheds Protection Act and the Wildlife Protection Act.

The provisions of these acts as well as others that affect Petrojam's operations (The Petroleum Act, The Draft Occupational Health and Safety Act, the Public Health Act, the Petroleum and Oil Fuel (Landing and Storage) Act, the Factories Act and the Harbours Act) are described in the EIA report.

The Jamaica Energy Policy (Green Paper) and the Draft Energy Sector Plan under Vision 2030 which help to guide Petrojam's long term plans are described. Other national policies (National Industrial Policy, National Land Policy and the policy for National System of Protected Areas) and international treaties that are relevant to Petrojam's activities are also described.

Identification and Assessment/Analysis of Potential Impacts

Methodology

A quantitative assessment of the overall project alternatives and analyses of the potential environmental (physical/chemical and biological) and socioeconomic (sociological, economic/macroeconomic) impacts during construction and after the upgrade was done.

The Rapid Impact Assessment Method (RIAM) was the tool used to make the assessment. The RIAM method provides an overall assessment where there are multi-disciplinary factors since the method allows data from different disciplines to be analysed against common important criteria within a common matrix, thereby providing a clear assessment of the major impacts. Such an assessment can be done for each project alternative and in the present case will be done for the "do nothing" case and for the preferred alternative (during construction and operation). The RIAM is based on two groups of assessment criteria and the means by which semi-quantitative values for each of these criteria can be assigned for the impacts in the four environmental components and then consolidated to give an overall assessment. The two groups of assessment criteria (A and B) are those that are of importance to the condition (group A scores are multiplicative to give total aT), and which can individually change the score obtained and those that are of value to the situation, but individually should not be capable of changing the score obtained (group B scores that are additive to give a total bT). The overall assessment ES is the product of the additive and the multiplicative sores (aTxbT)

Overall Assessment

The various ES values were grouped into ranges and assigned alphabetic or numeric codes so they may be more easily compared.

The methodology was applied to two of the three project alternatives – the "do nothing" alternative i.e., the existing situation as described and characterised in the baseline studies (Section 4), and the preferred alternative – the refinery upgrade project including the period during construction. Since the terminalling alternative is the least attractive and will not receive any consideration for implementation, it was not considered.

ASSESSMENT OF THE IMPACTS DURING CONSTRUCTION

It should be noted that all refinery activities will continue during the construction for the upgrade since the new processing units will be located mainly north of the existing processing area.

Physical and Chemical

Groundwater

Licences will be sought from the Water Resources Authority to drill new wells during the construction period. These wells will also serve water requirements after the upgrade). No adverse impact on ground water is likely since the licensed abstraction rate would take into consideration the overall capacity of the aquifer and its wells.

There will be ongoing recovery and cleanup of the leaked hydrocarbons from some of the tanks in the tank farm.

Construction (site preparation, demolition and construction) activities have the potential to affect surface water runoff, dust emissions/air quality and vibration.

Since the site is fully developed there will be minimal if any changes in the surface characteristics that would affect the quantity (i.e., flooding and drainage) of runoff during rainfall events. The magnitude of wave heights from storm surges would not be affected by construction activities.

Site preparation for foundation and other excavation activities may mobilise surface contaminants and sediment during rainfall events. The RUP processing area includes areas designated as potentially contaminated and hence excavation in this area could unearth soils contaminated with petroleum products. Since the degree of contamination is unknown it is recommended that a site assessment be done to determine the nature and extent of contamination in areas that would be excavated and the need for mitigative measures (e.g., remediation, safe management of contaminated excavated soils). Management of excavation and demolition piles will be necessary to mitigate the mobilisation and entrainment of suspended particles in runoff during precipitation events.

Site preparation, demolition, excavation and general construction activities have the potential to generate dust and noise. Control and protective measures will be put in place to mitigate dust emissions and noise and, where necessary, to monitor occupational noise exposure. It is anticipated that the ambient monitoring network established as a condition of Petrojam's air quality licences will be fully operational well before construction starts.

The potential vibration impacts during construction are from pile driving, excavation and compacting of soil. Typical vibration levels do not have the potential to cause structural damage. Some construction activities, such as pile driving can produce vibration levels that may have the potential to damage some vibration sensitive structures if performed within 30 m (100 ft) of the structure.

Annoyance from vibration often occurs when vibration levels exceed the human perception thresholds. These perception thresholds are at least 10 times lower than the damage threshold for normal buildings and are well below vibration levels at which damage could occur.

The refinery will continue to operate the existing processing units during the upgrade and no changes in the emergency response plans with respect to processing will be needed. The construction activities are governed by standard safety procedures. All staff engaged in construction activities will be required to undergo Petrojam's Health and Safety orientation and training. The training/orientation will include familiarisation with emergency response plans.

Biological Impacts

Potential terrestrial impacts during construction are negligible since the site is a well developed industrial site and no changes in the habitat are likely. Potential marine impacts due to construction activities can arise from runoff water that contains construction related sediment and hydrocarbon contaminants. The construction related discharges are not likely to be significant once mitigative housekeeping measures to reduce runoff affected by construction activities are put in place.

Socioeconomic Impacts

Land Use and Community Development

Land use by the proposed project will be limited to the existing Petrojam property and hence there will be neither land use impacts nor will there be any direct impacts on land use in surrounding areas. Construction activities will be concentrated in the central and eastern sections of the Petrojam site which is at least 0.5 km from the Greenwich Town Fishing Beach which is on the western boundary of the Petrojam site.

There will be indirect impacts on community development through employment opportunities for persons from the communities. This would reduce unemployment and increase residual income.

Public Perception

Survey results indicate generally very positive public perception about the construction phase although there were concerns about specific aspects (air pollution, hazardous waste) and in some cases indifference (proposed project would not affect them).

Employment and Income

Employment and income would be impacted positively by the proposed development. Petrojam has estimated that approximately 1,200 to 2,000 skilled jobs will be required during the construction phase of the project. Training programs especially within the communities adjacent to the refinery between now and when construction starts will be an important initiative to help secure employment opportunities for Petrojam's needs as well as for the spin off industries and services. A joint Petrojam/HEART program will provide such training.

Traffic

Increased traffic due to the increase in the construction work force and delivery of materials can easily be accommodated by the recently upgraded Marcus Garvey Drive. Where feasible the larger pieces of construction and process equipment will be moved by barge from the port to the Petrojam loading dock. When movement of such equipment by road is required mitigative measures will be put in place.

Heritage Sites and Community Activities

Since there are no heritage sites located within 0.5 km of the site there can be no impact on the heritage sites. The regular activities of the surrounding communities will not be affected by the construction activities for the upgrade.

Macroeconomic Impacts During Construction

The total project cost is estimated at US $758 million of which 25 -30% may be financed locally. The macroeconomic impacts will derive from increases in imports of construction and process equipment, in the supply of local construction materials and in wages earned by construction workers. The technical knowledge transfer for the design and construction will build local capacity that will be useful for other projects and industries.

IMPACTS AFTER THE UPGRADE

Physical and Chemical

Stormwater and Drainage and Wastewater

Process related wastewater from floor drains, process areas, chemical storage areas and equipment drains will be collected and routed to the wastewater treatment plant. The drains in the new process area will be designed to handle a 1 in 10 year storm event before overflow to the storm drains.

There will be negligible change in the amount of runoff to storm drains because of the upgrade so there will be negligible change in the runoff or potential for flooding (which does not occur at the site) or storm surge related impacts.

The upgrade will include a new wastewater treatment plant. The plant will incorporate and upgrade the existing API separator and will include secondary treatment to meet NEPA trade effluent standards.

Air Quality

The upgrade will require new process heaters for various process units, a new boiler (and associated new stacks) and a new flare. The existing vacuum furnace and three existing boilers will be retained. Because of the increased throughput of the refinery, maximum capacity emissions of SO_2, NOx, CO, PM and VOC will increase by 89%, 17%, 107%, 252% and 400% respectively. Although the percentage increase in VOC emissions from point sources is large the absolute VOC emissions from point sources is small relative to the other contaminant emissions. VOC emissions from storage tanks and loading operations will be similar before and after the upgrade since the total amounts of finished products loaded and/or stored will be similar. This is because the reduced imports of finished products will be offset by products made in the refinery. The percentages of Petrojam's emissions in the Kingston airshed's point source emissions before and after the upgrade are shown in Table 3. After the upgrade greenhouse gas emissions will increase by 84% for CO_2, 138% for CH_4 and 173% for N_2O.

Although the percentage increases in Petrojam's emissions for the various gases are large (they will nearly double or more several cases) the emissions should be viewed relative to other emissions in the Kingston airshed in order to get an indication of overall air quality impact. Air dispersion modelling provides a means to predict the overall impact as well as the impact from Petrojam's future (and existing) emissions.

The model predictions show that predicted SO_2 concentrations due to Petrojam sources alone are of potential concern both for the existing situation and after the upgrade since the highest predicted concentrations exceed the corresponding NRCA air quality standards. Predictions for CO and TSP are well below all of the corresponding NRCA standards and therefore are not of concern. In the case of NO_2, the prediction for Petrojam sources alone are well below the standards but when all sources in the airshed are considered the 1 hour Guideline Concentrations is predicted to be exceeded but this would be due to another source or sources in the airshed.

Table 3 Summary of Petrojam's Emissions Share of Point Sources in the Kingston Airshed

	SO_2	NOx	PM	CO	VOC
Petrojam's Share (%) Existing	16	1.2	13	0.2	15
Petrojam's Share (%) After Upgrade	26	1.4	24	0.9	1

Unfortunately there are very limited ambient monitoring data with which model predictions can be compared. Based on the monitoring data obtained at sites near the Petrojam refinery during the EIA, it is clear that the model over-predicts the SO_2 concentrations. In any event, as one of the conditions of the air quality licences for the Petrojam and JPS Hunts Bay station, ambient monitoring for SO_2, NOx, and PM_{10} will take place at three stations near the facilities. The monitoring data from these stations will provide continuous and reliable information on air quality in the vicinity of the two facilities.

Another way of examining the impact of the upgrade is to determine whether or not the predicted change in air quality is "significant". The Guideline Document provides the definition of "significant". The dispersion model results in relation to the test of significant impact are shown in Table 4. If the increase in the model prediction as a result of the upgrade is below the criterion the impact is deemed not significant. The data are somewhat inconclusive since the SO_2 and NO_2 results for the 24 hour (shaded cells) show that the changes are significant but the results for the annual average indicate that the impacts of the upgrade are not significant.

Table 4 Summary of Dispersion Modelling Results to Test Significance of Air Quality Impacts

Pollutant	**Averaging Period**	**Maximum Predicted ($\mu g\ m^{-3}$)**		**Increment ($\mu g\ m^{-3}$)**	**Significance Criterion ($\mu g\ m^{-3}$)**
		Existing	After Upgrade		
SO_2	24 hr	551	704	153	80
	Annual	97	110	13	21
TSP	24 hr	36	44	8	80
	Annual	6	6.5	1.5	21
NO_2	1 hr	86	233		
	24 hr#	50	135	85	80
	Annual	1	5	4	21
CO	1 hr	25	122	97	2000
	8 hr	10	17	7	500

Estimated from the 1 hr results based on equation 9-1.

Health Risk Assessment

The Terms of Reference for the EIA required a health risk assessment to identify human health risks due to the existing refinery operations and to determine any incremental risks due to the refinery upgrade. The health risk assessment was based on the methodology indicated in the NRCA *Guideline Document* which is an integral component of the NRCA Air Quality Regulations. A screening process identified benzene as the only compound of potential concern since a) it has the lowest limit of the compounds included in ambient VOC measurements; and b) some of the 24 h average concentrations that were measured in the vicinity of the Petrojam site were higher than the 24 h limit).

Risks associated with emissions from the refinery were estimated by comparing the exposure rates predicted by the model at a number (146) of special receptors with established toxicity reference values (TRVs). Since the benzene emissions will be similar before and after the upgrade it was necessary to make only one set of model predictions. The special receptors included schools, hospitals, the nearest residences and ambient monitoring stations. TRVs are established by regulatory agencies (e.g., US EPA, California Air Resources Board, Health Canada or the Ontario Ministry of the Environment) and are based on animal toxicity tests or human epidemiological studies. These TRVs are rates of exposures to which the persons can be exposed without harmful human health effects. Risks are estimated by directly comparing the rate of exposure to the TRV. The TRVs used in this report were taken from the USEPA's Integrated Risk Information System (IRIS) and the California Air Resources Board. The reference concentration (RfC) was used to assess non-carcinogenic inhalation effects and inhalation unit risk (IUR) provided on IRIS and ARB to assess carcinogenic effects. Since IRIS (US EPA) and ARB provided TRV values, the lower (more stringent) value was used to evaluate the hazard quotient. Acute effects were assessed by comparing the highest predicted 1 hr benzene concentration to the acute reference value.

The hazard quotient (HQ), which is the ratio between the concentration to which a person is exposed and the RfC, is used to assess non-cancer hazards. Regulatory agencies agree that a hazard quotient value below one (1) is not significant – that is no adverse health effects would be expected. A HQ greater than one indicates that there is a potential for adverse health effects.

Estimates of the exposure were made at 146 receptors which included monitoring stations used in the EIA, the residences nearest to the refinery, schools, hospitals and health centres in the airshed. At the special receptors, non-cancer health risks associated with acute exposure to benzene remained significantly below the target HQ of 0.6 except for one of the monitoring stations NW1. Similarly for chronic exposure – based on the highest predicted daily average benzene concentration, two monitoring station receptors have hazard quotients greater than 0.6.

Six of the 146 receptors – namely five monitoring stations as well as at the nearest residence to the northwest (NRNW) had incremental lifetime cancer risks (ILCR) that were greater than 1 in 1,000,000: the ILCR values at the remaining 123 non-occupational receptors (i.e., excluding those within Petrojam's property) are less than 1 in 1,000,000 and hence the exposures at these receptors were considered negligible.

At 1 x 10^{-5} (1-in-100,000), Health Canada considers the risk to be essentially negligible. Five receptors NW1, NW2 and BH have incremental cancer risks between 10^{-5} and 10^{-6}. Only at the loading rack – which is on Petrojam's property was the incremental lifetime cancer risk greater than 10^{-5}.

The frequencies with which exceedances of the 1h and 24 h limits occur at the five receptors range from 0.05% of the time to 2.0% of the time. This low frequency of occurrence would be likely to require much less urgent action in other jurisdictions e.g., Ontario for example especially if the frequencies were based on measured values.

It is prudent to err on the side of caution and we recommend that the risks due to benzene exposure by the existing refinery should be examined further at receptors in the vicinities of the nearest residences, the loading rack and also at the monitoring stations near the refinery. The first step in such examination is to conduct additional ambient monitoring for benzene. In making the recommendation we are discounting a) the conservative (high) emission rates used in the model, b) the likelihood that the model over predicts, c) the loading rack site should be treated in an occupational exposure context and d) the conservative nature of the unit cancer risk factor.

It is clear however that since the benzene emissions will be similar before and after the upgrade that the upgrade will not pose any additional risks.

Vibration Impacts

Vibration impacts that can arise from spinning or vibrating equipment (e.g., pumps, compressors, motors) are also unlikely to affect adjacent properties since such equipment will be located almost exclusively in the processing area. It is only feasible to determine these impacts from manufacturers' specifications and these are not yet available. The potential impact of vibration on Petrojam's structures will be an important aspect of the design and will be taken into consideration in due course.

Emergency Response Plans

Petrojam's existing Process Safety Management program and the philosophy and objectives of the Health, Safety, and Environmental Management (HSEM) program will be retained but the various plans will be adapted to reflect the physical changes as well as to introduce measures that are required for the new processing units.

Biological Impacts

Potential terrestrial and marine impacts because of the upgrade are negligible since the site is a well developed industrial site and no changes in the habitat are likely. After the upgrade the potential will remain for entry of petroleum products to an already impacted harbour ecosystem. While the possible impacts of petroleum product toxicity and sedimentation / turbidity may not be as severe as would be the case with healthier reefs the relative impacts on these systems have the potential to be of critical importance to the survival of both harbour and reef systems.

The new wastewater treatment plant is designed to meet NEPA's trade effluent standards (including oil and grease) and will dramatically reduce the potential for oil from the upgraded refinery reaching the harbour. Because of this marine impacts from hydrocarbons after the upgrade would be reduced.

Socioeconomic Impacts

Employment

It is estimated that over 185 new, permanent skilled positions will be needed after the upgrade and there will also be increased demand for skilled and unskilled contract workers. Members of the local community will need to take advantage of the training opportunities in order to help secure such job opportunities.

Land Use, Traffic and Community Development After the Upgrade

There will be no change in land use after the upgrade since the project will be entirely within the current property boundaries.

The quantity of finished products that will leave the site via tank trucks or ship (barges) should not change because of the upgrade. However, there will be increased marine traffic for the importation of larger amounts of crude oil and for the export of vacuum gas oil as well as sulphur. The new product petcoke will be transported to the JPS Hunts Bay Plant, which is located immediately east of the site, via a dedicated conveyor belt system, and will therefore not impact any road or marine transportation networks.

The upgrade should result in positive impacts on the community/community development because of the potential for increased employment opportunities at Petrojam for persons in the nearby communities. This in turn would positively affect other economic activities such as providing services and spending on consumer goods. The upgrade should not affect the normal community activities in adjacent nearby communities.

Public Perception

The public perception (based on survey and other data) was generally very positive about the project although there were concerns about specific aspects (air pollution, hazardous waste) and in some cases indifference (proposed project would not affect them).

Macroeconomic Impacts

The upgrade will allow the use of heavier lower cost crude oils thus adding flexibility (and hence security) in the sources of crude. It will diversify the sources of finished products and eliminate the need to import higher cost gasoline and diesel. The upgrade will also produce vacuum gas oil, diesel and sulphur in excess of local demand and these will be exported – earning additional foreign exchange. The net foreign exchange savings were estimated at US $100 million, although this will depend on regional prices for petroleum products. .

The upgrade will allow the production of petcoke which will be used by JPS in a 120 MW electricity generating station. The use of petcoke is expected to lower the overall cost of electricity generation. The petcoke electricity generating plant will require limestone from local quarries and will also produce ash which can be used in road construction or as an additive for cement further enhancing the national benefits of the project.

Other Cumulative Impacts

The production of low sulphur diesel for use in newer technology diesel engines as well as existing engines will reduce tailpipe emissions from these engines. The reduced emissions will have positive impacts on air quality and human health.

The improved wastewater treatment plant will allow Petrojam to meet and even exceed NEPA trade effluent standards and should have a positive impact on the water quality in Kingston Harbour.

Quantitative Impact Assessment

Quantitative assessment of the impacts in all study disciplines were assessed for the current situation, during construction and after the Refinery Upgrade using the rapid impact assessment matrix (RIAM) method.

The overall assessments for the three scenarios (Existing, during construction and after the upgrade) are presented in Table 5. The assessment shows that the most positive impacts are from the sociological and economic aspects (the ES or RV values are more positive than the existing situation); there is no significant change in terrestrial or physical impacts but there is deterioration in the marine aspect. The negative impacts for marine impacts are due to the increased marine traffic and the greater potential for marine accidents. These point to greater vigilance in preventive measures for shipping (loading/unloading of raw materials (crude) and products or intermediates that are shipped.

Mitigation and Monitoring

The assessments for the existing and upgraded refinery indicate the need for mitigation and or monitoring during construction and after the upgrade in the following areas:

- Seismic and hurricane impacts
- Ambient Air Quality
- Occupational Exposure
- Vibration
- Surface and groundwater
- Biological
- Socioeconomic

Table 5 Summary of Quantitative Impact Assessment

Activity/Discipline	**Existing**		**During Construction**		**After the Upgrade**	
Parameter	**ES**	**RV**	**ES**	**RV**	**ES**	**RV**
Physical and Chemical Components	***-174***	***-5***	***-251***	***-5***	***-113***	***-5***
Hydrology (Ground and Surface water)	-24	-3	-78	-5	-48	-4
Storm Surge	-5	-1	-5	-1	-5	-1
Marine Water Quality Impacts	-96	-5	-108	-5	0	0
Gaseous emissions	-42	-4	-42	-4	-52	-4
Occupational	-7	-1	-18	-2	-8	-1
Noise	0	0	0	0	0	0
Solid Waste Management	-6	-1	-30	-3	-6	-1
Biological and Ecological Component	***-14***	***-2***	***-14***	***-2***	***-28***	***-3***
Terrestrial	0	0	0	0	0	0
Marine	-14	-2	-14	-2	-28	-3
Sociological and Cultural Components	***20***	***2***	***60***	***3***	***96***	***4***
Economic and Operational components	***-22***	***-3***	***30***	***2***	***94***	***4***

Mitigation and Monitoring

The mitigation and monitoring during construction and after the upgrade are summarised in Table 6.

Environmental Management and Monitoring

Petrojam has a formal, documented and well established environmental management system and industrial hygiene program. In both cases the purpose is to ensure sound practices and to meet applicable local and international standards and guidelines.

Reporting

Quarterly monitoring reports will contain the results of all monitoring, photographic or other observations that are made in the reporting period as well as recommendations for action, if required, for improving the construction process from an environmental perspective and adjustment of the frequency of monitoring.

Table 6 Summary of Mitigation and Monitoring

Activity/Aspect	Mitigation	Monitoring
Physical and Chemical		
Seismic and hurricane impacts	Structural designs will conform to the National Building Code including seismic design criteria of 40% g consistent with a high risk earthquake area and to withstand 3 second wind gusts of 155 mile/hr.	Not applicable
Ambient Air Quality	No point source mitigation until data from continuous monitoring is evaluated – since comparison of EIA monitoring data and model predictions indicate that the model over-predicts	During construction: Establish 3 ambient monitoring stations for hourly averaged SO_2, NOx, wind speed & direction, daily averaged PM_{10} every 6th day: one station with hourly averaged total reduced sulphur (TRS).
Occupational Exposure	Reducing dust (e.g., wetting unpaved areas, cleaning and wetting if necessary paved areas) from general construction activities. Wearing of protective hearing devices, eye protection and breathing devices and also adherence to good housekeeping practices.	Two additional on-site TSP monitoring stations – every 3rd day adjusted based on constructions activities. Two speciated VOC monitoring surveys using passive samplers at (at least) 6 sites including nearest residences & loading rack. Continue monitoring of total hydrocarbons, SO_2 using Drager tubes. Monitor noise levels in the vicinities of where noise generating activities take place and at three perimeter locations during construction.
Vibration	Survey buildings within 100 m of pile driving. Limit times when pile driving etc take place	Monitor input from occupants of buildings in adjacent properties.
Surface and groundwater	The abstraction rate of water from additional wells will be closely monitored and test wells and monitoring the level of the water table will be carried out to ensure the abstraction rate is sustainable and within the licensed rate. Good housekeeping (removal of debris, minimising sizes of earth piles, maintenance/clearing of storm water drains, avoiding concrete washings from reaching storm drains) to minimise surface water runoff from construction/demolition debris and earth excavation piles and concrete mixing will be minimised by good housekeeping practices	Monitor abstraction rate and water table Introduce measurements of effluent flows for storm water and trade effluent and composite sampling to monitor various trade effluent parameters (Total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), conductivity, oil and grease, sulphide, pH, chemical oxygen demand (COD) and phenol). The samples frequency would be initially every other day and adjusted based on wastewater treatment plant performance.

Activity/Aspect	Mitigation	Monitoring
Biological	Protocols for maintenance activities associated with cleaning of tanks will be revised to ensure that sandy/sediment containing wash water is collected so that the sediment/sandy material is allowed to settle before treatment and discharge of the supernatant. The sediment/sandy material will be disposed of in a landfill or other suitable/approved method.	Marine/Ecological Monitoring of marine water quality (monthly at outfalls and background sites) and the composition of marine, (benthic, pelagic) species (quarterly) during construction. The monitoring frequency would be adjusted based on monitoring results.
Socioeconomic Training/Employment	Implement training programs for persons in adjacent communities so they could take advantage of jobs during construction and after the upgrade.	None
Traffic	Movement of large and/or heavy pieces of equipment from the wharf to the site by barge where possible. When movement by road is required traffic impacts will be mitigated by making traffic management and other arrangements with various authorities (KSCA, JPS, Police, NWA etc.) and schedule such movements at night or other low traffic (week end) periods.	
Communication/Emergency response	Expand the Terms of Reference for the existing Community Outreach Committee to include engagement of the surrounding communities in emergency response planning in order to improve communication about emergency response and appropriate involvement of the community in emergency response.	

1 INTRODUCTION

This report presents the Environmental Impact Assessment (EIA) for the proposed upgrade of the Petrojam Limited refinery located at 96 Marcus Garvey Drive in Kingston, Jamaica. The purpose of the upgrade is to expand the capacity of the refinery from 35,000 barrels per day (bpd) to 50,000 bpd. The upgrade will entail the addition of process and waste treatment units for both liquid and gaseous effluents that use mature refinery technologies and which will allow the production of higher value refined petroleum products and better treatment of effluents from the refinery.

The upgraded refinery will see the addition of the following main process units and key waste treatment facilities for both liquid and gaseous effluents.

Existing Units Being Upgraded

- Crude Distillation Unit
- Gas Recovery Unit
- Kerosene Hydrotreater
- Main New Process Units
- Distillate Hydrotreater
- Naphtha Hydrotreater
- Continuous Catalyst Regeneration Platformer Unit
- Vacuum Unit
- Delayed Coking Unit

New Effluent Treatment Units

- Sour Water Stripper
- Amine Absorber
- Sulphur Recovery Unit
- Tail Gas Treatment Unit
- Waste Water Treatment Plant

The National Environment and Planning Agency (NEPA) determined that the project will require an EIA, the Terms of Reference for which (see Appendix 1) were finalised after consultation with and input by interested stakeholders.

This EIA report addresses all of the items specified in the TOR. Table 1-1 shows where in this document the various aspects and requirements of the TOR are addressed.

Table 1-1 Road Map Indicating Where TOR Items are Addressed in the EIA Document

Aspect (Task)	EIA Section
1) Objectives	1,1.1
2) Complete description of the existing site proposed for development (including storm surge analysis) (Task #1: Description of the Project)	1.2 4.1.3, Appendix 9.2, 4.7
3) Significant environmental issues of concern through the presentation of baseline data which should include social, cultural and heritage considerations. Assess public perception of the proposed development (Task #2: Description of the Environment Baseline Studies Data Collection and Interpretation Physical environment Biological environment Socio-economic and cultural constraints) Task #5: Drainage Assessment Task #9: Public Participation/Consultation Programme	 4 4.1 – 4.7 4.12 4.13 4.6 3
4) Policies, Legislation and Regulations relevant to the project (Task #3: Policy, Legislative and Regulatory Considerations)	 5
5) Likely impacts of the development on the described environment, including direct, indirect and cumulative impacts, and their relative importance to the design of the development's facilities (Task #4: Identification and Assessment/Analysis of Potential Impacts)	6
6) Mitigation action to be taken to minimise predicted adverse impacts and quantify associated costs (Task #6: Mitigation)	7
7) Monitoring Plan which should ensure that the mitigation plan is adhered to (Task #7: Environmental Management and Monitoring Plan)	7
8) Alternatives to the project that could be considered at that site or at any other location (Task #8: Project Alternatives)	2
9) Conclusions	7

In addition to addressing NEPA's Terms of Reference for the EIA, the conduct of the EIA and the EIA document itself also took into account and addressed requirements of the Equator Principles (see Text Box) and the environmental and social standards of the International Finance Corporation (IFC), an institution of the World Bank Group that is responsible for transactions with the private sector.

These aspects are addressed because of the project financing requirements. Application of the principles is required for financing projects that are greater than US $10 million.

Most if not all of the requirements of the Equator Principles are embodied in NEPA's EIA procedures and in the Terms of Reference for this EIA. A detailed evaluation of the equator principles is provided in Appendix 2.

The requirement to conform to the IFC performance standards is also met in large part by NEPA's Terms of Reference for this EIA. Since Jamaica has national environmental standards these are given priority. Where no national environmental standards exist, World Bank or other jurisdictions' standards or guidelines are cited.

What are the Equator Principles?

The "***Equator Principles***" are a financial industry benchmark for determining, assessing and managing social and environmental risk in project financing. The Equator Principles were developed by private sector banks and were launched in June 2003. The banks chose to model the Equator Principles on the environmental standards of the World Bank and the social policies of the International Finance Corporation (IFC).

Their adoption seeks to ensure that the projects financed are developed in a socially responsible manner and reflect sound environmental management practices. Hence negative project impacts on ecosystems and communities are avoided where possible, reduced where they are unavoidable, and mitigated and/or compensated for appropriately. Adoption of the Equator Principles is voluntary, unilateral commitment to perform a detailed analysis of environmental and social aspects of each new project financing and to link financing to compliance with a number of requirements.

See www.equator-principles.com for additional details

1.1 NEED FOR THE PROJECT

The Petrojam Refinery Upgrade Project is designed to position the refinery to be more competitive and viable for the long term so that it can provide reliable and cost effective energy supplies for Jamaica on a sustainable basis.

The project is of national importance, as it is expected to achieve a number of technical and national objectives, of which the most important is as follows.

Enabling a reduction in the importation of finished petroleum products through upgrade of the refinery capacity and re-alignment of its process configuration to match product yields with market demand; production of more environmentally friendly petroleum products; and assuring continued ability to supply petroleum products at least cost, by increasing its profitability through use of cheaper, heavier crude oils and the production of proportionately higher valued products from the crude oil raw material.

1.2 STUDY AREA

The Petrojam Limited Refinery site is located at 96 Marcus Garvey Drive in the parish of St. Andrew (see area within the circle in Figure 1-1. The study area for various aspects of the EIA is dependent on the particular aspect. The sizes of the study areas for the various aspects are as follows:

Occupational	On site
Marine ecology	200 m off shore the site inside Kingston Harbour
Water quality	
Marine	200 m off shore and inside Kingston Harbour
Wastewater	On-site and 50 m offshore (outfall)
Socio-economic	Within a 3km radius surrounding the site
Heritage sites	Within a 0.5 km radius surrounding the site
Geology	Onsite
Hydrology	Within a 2 km radius surrounding the site
Air quality and Human Health Effects	See Figure 1-1

The air quality study area (see entire Figure 1-1) is the largest because of the potential for the dispersion of airborne emissions from the facility. Further details of the study areas are provided in the sections that address the various aspects.

Figure 1-1 Map of West Kingston - Jamaica, showing the Location of the Petrojam Limited Refinery Site

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2 PROJECT ALTERNATIVES AND SELECTED PROJECT

Options for upgrading the equipment at the Petrojam refinery have been under study for several years. Various options for the upgrade were based on upgrading or replacing some existing units and adding new process and waste treatment units. The upgrade will allow the production of low sulphur diesel and gasoline fuels and petroleum coke[1]. Without the upgrade the existing refinery would not be able to produce low sulphur fuels needed to satisfy the diesel requirements of post 2007 diesel engines. The upgrade options also included the production of coke for a proposed expansion of electricity generating capacity at the nearby Jamaica Public Service Company Limited (JPS) Hunts Bay Generating Station. In addition to the proposed options for a refinery upgrade project, Petrojam also considered a terminalling option and the do nothing alternative.

2.1 ANALYSIS OF PROJECT ALTERNATIVES

2.1.1 Do Nothing Alternative (No Upgrade)

The do nothing alternative would mean that the refinery would not be able to meet the demands of unleaded gasoline since the current Catalytic Reduction Unit (CRU) cannot produce sufficient quantities of gasoline feedstock with the required octane.

2.1.2 Terminalling Option

The Terminalling option would discontinue crude oil processing at the refinery and operating the facility as an import terminal. Under this option the facility would import, store as needed and sell all products.

The closure of the refinery would entail decommissioning the existing processing equipment to make it safe and hydrocarbon free. The estimated expenditure would be US $1 million. The operation of the terminal would mean a reduction of the number of employees by 70% and there would be additional severance payments for departing employees.

The Terminal would need about 30% of the current workforce. Maintenance costs would be reduced to that needed to operate the dock, tank farms and loading racks and are estimated to be about 35% of current maintenance costs.

This option would also mean that the current benefits related to government–to-government agreements for the supply of crude would be lost and the multiplier effect from lost salaries on the local economy would also be lost. Assuming a multiplier of 2.5 the annual loss to the economy is estimated at about US $10 million. This option would also result in lost taxes and local service contracts.

2.1.3 Two Phased Refinery Upgrade Project Option

A two-phased refinery upgrade option as follows was initially considered.

The Original Phase I Scope (at an estimated cost of US$212 million), was as follows:

- Upgrade of the refinery crude capacity from 35,000 barrels per day (35 kbbls/day) to 50 kbbls/day
- Installation of a new catalytic reforming unit (CRU) with increased capacity of 7,500 bbl/day to fully meet Petrojam's market demand from production
- Installation of a Diesel Hydrotreater Unit (DHT) capable of producing ultra low sulphur diesel (ULSD) with 15 ppm sulphur, vs. the 5000 ppm now being produced.
- Installation of a new Vacuum Distillation Unit (VDU) with a nominal capacity of 30 kbbls/day with the capability to produce approximately 10-12,000 bbl/day of vacuum gas oil for export
- Installation of a new Visbreaker Unit (VBU), capable of converting a portion of the Heavy Fuel Oil (HFO) into higher valued products such as gasoline and diesel oil.
- Installation of a Sulphur Recovery Unit (SRU) to enable environmental emission standards to be met, while producing about 30 tonnes/day of sulphur for sale.
- Installation of other environmental treatment units to meet emission requirements for air quality and water effluents

The Original Phase 2 Scope was:

- Installation of a 15,000 bbl/day Delayed Coker Unit (DCU), which would convert all of the Heavy Fuel Oil residue into the more valuable products of gasoline and diesel oil, as well as the by-product, petroleum coke (Petcoke).
- Installation of a cogeneration facility that would use the petroleum coke from the DCU as fuel for generating approximately 100 MW of electricity for sale to the public power company.

Technical and Other Issues

Following the start of the front end engineering design (FEED) study in March 2006, there have been several significant deviations from the original design assumptions. The implication is that the internal rate of return (IRR) for the project will be reduced from the original 17.5% to 12.6%. The project needs to achieve an IRR of approximately 15% to be viable. It should be noted that given the dynamic nature of the petroleum industry, a project that may appear to be viable when an investment decision is taken may not remain viable during implementation arising from changes in important parameters. Hence, adjustments and re-alignment of a project during implementation is sometimes necessary. This is the case with the Petrojam Refinery Upgrade Project.

The following are some of the significant changes which are unavoidable.

(a) Elimination of Visbreaker Unit

The features of the Visbreaker Tar from heavy Venezuelan crude preclude any significant addition of "virgin" (paraffinic) blendstocks. This means that a large quantity of relatively expensive light cycle oil (LCO) would need to be imported as diluents for the visbroken heavy fuel oil (HFO) to meet technical specifications. This will have an adverse economic impact.

Based on the results of a market study done by consultants (Purvin and Gertz) for the refinery upgrade, the market for LCO is small and supply is restricted. Hence, reliability of supply would a significant risk factor. It should be noted that most refineries that have Visbreakers also have Fluid Catalytic Cracking (FCC) Units that produce the LCO required for blending with the Visbroken HFO. An FCC Unit was <u>not</u> included in the scope of the Petrojam Refinery Upgrade Project, as its significance for the provision of cutterstock for the visbroken HFO was not known at the time. Also, given the intention to implement a Delayed Coker in Phase 2, the FCC would not have been a necessary step towards this final configuration.

It is worthy to note that, apart from the economics, the lack of availability of cutterstock for the Visbreaker Tar, by itself, renders the Visbreaker an infeasible selection.

(b) Unstable 3% S HFO Market

The original assumed market for high sulphur HFO was 6,000 bpd based on anticipated market loss due to the introduction of LNG into Jamaica. However, since then Petrojam has obtained an additional 14,000 barrels per day in Ships' Bunker sales through a joint arrangement with Aegean Marine. This increased outlet for high sulphur fuel oil erodes the economics of the Coker by increasing the value of the Coker feed stream. In addition, the long term security of the Bunker market is an issue, as whilst there currently appears to be very good prospects for developing a significant bunker market in Jamaica, there will invariably be increasing pressure on prices to sustain volumes. The bunker market in the medium to long term could therefore be regarded as being more unstable and unpredictable than the local market for 3.0% S HFO.

(c) Capital Cost Escalation

The estimated capital cost for Phase 1 has increased from US$212M to US$374M, primarily caused by the general escalation being experienced by the oil industry worldwide, and also by an increase in the scope of the project as explained below. Excluding the US$60M which can be attributed to an increase in the scope of the project, projected escalation is in the order of 48%. However, this is not out of line with the 53% quoted by Cambridge Energy Research as being the average increase for Oil & Gas projects over the last two years.

Included in the original scope of work for FEED Study was a requirement for SNC Lavalin to perform a study on the inclusion of electricity generation in the project. Petrojam took the decision that a 20MW Cogeneration plant was mandatory because of the unreliability of the public electricity supply. This component was also economic due to the very high cost (US$0.20/KWH) of local electricity. This component means a US$48M increase in the capital cost. The other major increase in the scope of the project is a $12M upgrade to the naphtha hydrotreater to handle the high nitrogen[4] levels in naphtha encountered in the Leona 22 test run, as well as on Mesa crude.

2.1.4 Selected Single-Phase Refinery Upgrade Project Option

Project Re-evaluation

Based on the factors cited previously, a re-evaluation of the option of incorporating the Coker-Cogeneration configuration into Phase 1 was conducted. This re-evaluation was initiated towards the end of 2006, during which, a number of other process options were screened. This work was done by the project consultants, Muse & Stancil. The block diagram for the selected refinery upgrade option is shown in Figure 2-1.

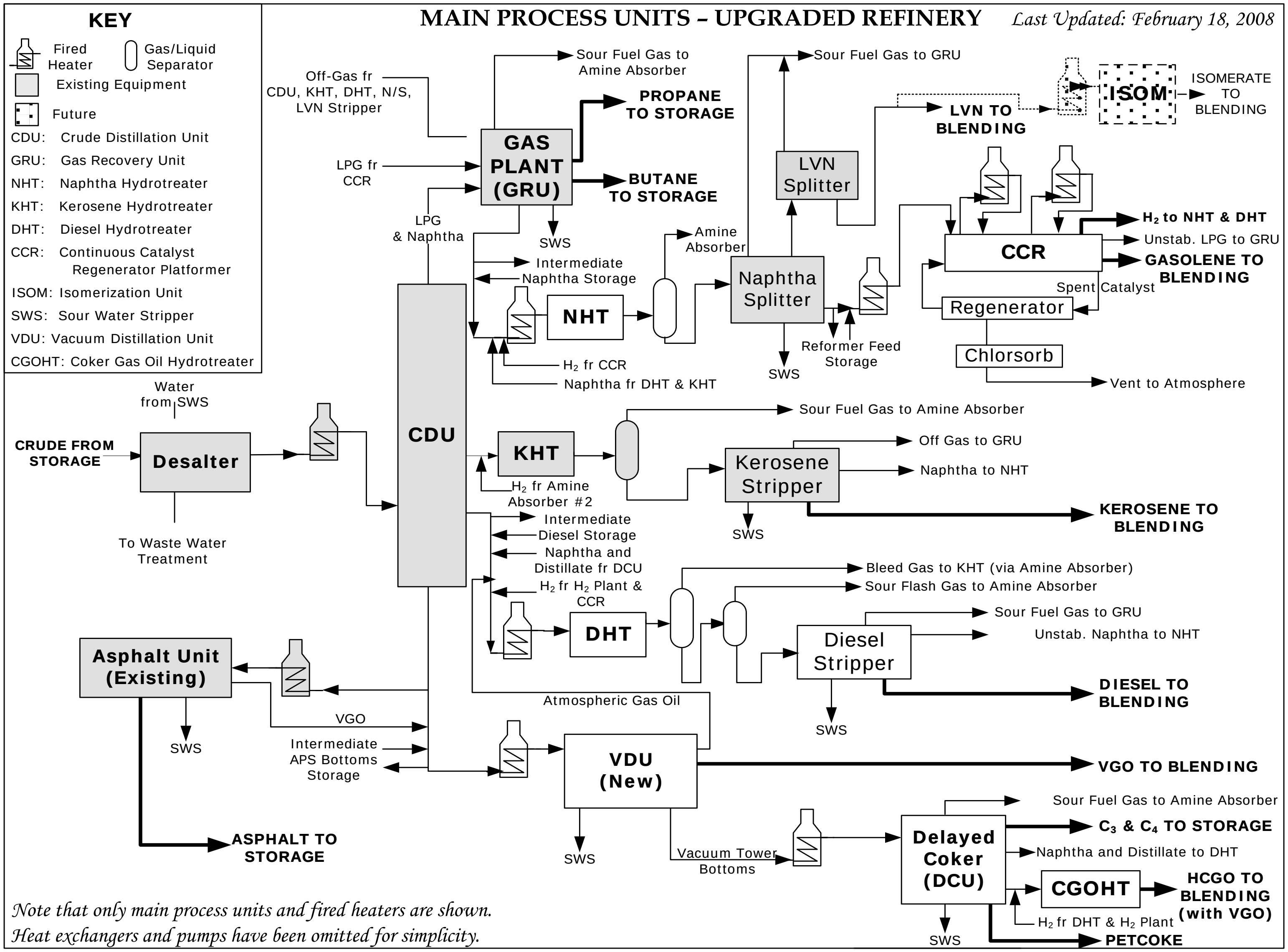
After careful review of the economics of all the options, coupled with considerations associated with technical and strategic issues, the Coker Case has emerged as the selection of choice. The results show that the new costs for Phase 1, with the Delayed Coker incorporated, would be US$512M.

It should be noted that the indicated higher return Case 5, (i.e. the FCC/Visbreaker configuration) was rejected because:

(i) When adjusted for a mandatory 20MW electricity Cogeneration plant would yield the same return as the Coker case; and

[4] Nitrogen is deleterious in refinery processing, as it poisons reactor catalysts and promotes corrosion.

Figure 2-1 Block Diagram – Selected Refinery Upgraded Option



(ii) It did not meet the strategic objectives of eventually eliminating fuel oil production. The other Cogeneration cases were also rejected because of high capital costs and similar returns to the Coker case.

For the Delayed Coker Option, prior to any adjustments, the real internal rate of return is approximately 12.6% which is marginally below the 15% hurdle rate. However, the expected real internal rate of return is approximately 16.4%, with the following adjustments incorporated into the economic model:

The Petcoke will be used by JPS at their adjacent site at Hunts Bay, which would reduce the costs (approx. $50 million), of the handling and dock facilities required to export it, as originally assumed. The price obtained for the sale of the Petcoke to JPS is better than the export disposal price, but still significantly more competitive than the cost of coal.

No HFO would be imported for re-selling as bunker fuels. Positive response has been indicated by the Petrojam Joint Venture Partners, PDVSA of Venezuela for the proposed course of action in relation to the Refinery Upgrade project, and they are similarly currently engaged in obtaining final approval from their Government.

2.2 DESCRIPTION OF THE SELECTED PROJECT

The upgraded refinery will see the addition of the following main process units and key waste treatment facilities for both liquid and gaseous effluents.

Existing Units being upgraded

- Crude Distillation Unit
- Gas Recovery Unit
- Kerosene Hydrotreater

Main New Process Units

- Distillate Hydrotreater
- Naphtha Hydrotreater
- Continuous Catalyst Regeneration Platformer Unit
- Vacuum Unit
- Delayed Coking Unit

New Effluent Treatment Units

- Sour Water Stripper
- Amine Absorber
- Sulphur Recovery Unit
- Tail Gas Treatment Unit
- Waste Water Treatment Plant

Crude from storage tanks will be passed through the existing Desalter for salt and solids removal, then pre-heated in a set of heat exchangers and then finally to the desired temperature in a fuel oil fired furnace (as is currently the case) before entering the upgraded

Crude Distillation Unit (CDU). There will be five streams from the CDU: liquefied petroleum gas (LPG), naphtha, kerosene, distillate and fuel oil.

LPG

LPG and naphtha from the CDU will be fed to the Gas Recovery Unit (GRU). The GRU will consist of a series of heat exchangers and distillation towers where the naphtha is separated from the LPG and routed to the Naphtha Hydrotreater. Gases lighter than propane will subsequently be removed from the LPG and routed to the fuel gas system after H_2S is removed in the Amine Absorber. LPG (i.e. propane and butane) are separated from each other and sent to their respective storage facilities.

Naphtha (Gasoline Precursor)

Hydrogen-rich treat gas is added to the naphtha from the GRU and the combined stream heated in a pre-heat exchanger then in a fuel gas fired heater. The heated naphtha-hydrogen stream will then be fed to a new Naphtha Hydrotreater (NHT) for sulphur removal.

Hydrotreated naphtha will be fed to a Naphtha Splitter where light sour gases will be removed. Additionally, light virgin naphtha (LVN) will be separated from feed to the Continuous Catalyst Regeneration (CCR) Platformer and sent to tanks for gasoline blending.

In the CCR, naphtha will be upgraded to gasoline in a series of fuel gas fired heaters and catalytic reactors. Chlorides (in the form of perchloroethylene, PCE) will be added continuously to the reactor feed to ensure optimum catalyst activity. Hydrogen will be produced during the reforming reactions, some of which will be recycled to the CCR. The rest of the hydrogen will be compressed and sent to the Naphtha and Distillate Hydrotreaters. The gasoline product will be stripped of light gases in a distillation column then sent to tankage for blending. The stripped gases will combine with other gases to the Amine Absorber.

The key feature of the CCR is the continuous regeneration of the catalyst, whereby coke deposits are burnt off. Chlorides are inevitably released from the catalyst during regeneration and are present in the vent gas as hydrochloric acid (HCl). There are two main options for HCl removal from vent gases: caustic scrubbing or use of an absorption system (Chlorsorb®). The Chlorsorb® method was chosen as it eliminates the use of caustic and hence the need to dispose of spent caustic. The Chlorsorb system is thus the environmentally friendly solution for reducing chloride emissions from a CCR Platforming unit. There is virtually no waste associated with the use of Chlorsorb®.

Note that there is also the option to add unhydrotreated naphtha from storage to the NHT, and also to add hydrotreated naphtha from storage to the CCR.

Kerosene

As with the existing refinery, kerosene from the CDU will be combined with hydrogen treat gas then fed directly to the Kerosene Hydrotreater (KHT) for sulphur removal. Hydrotreated kerosene will then enter a Kerosene Stripper where light gases (hydrocarbons, H_2S, H_2) will be removed and sent to the fuel gas system after sulphur recovery. The kerosene product will then be sent to tanks for blending. Note the light gases are burnt as fuel and are not released to the atmosphere.

Distillate

Downstream processing of distillate is similar to that of kerosene. Distillate from the CDU and Delayed Coking Unit (DCU) will be combined with hydrogen-rich treat gas then heated in a new fuel gas fired furnace and fed to a new Distillate Hydrotreater (DHT). Hydrotreated distillate (diesel) will then be fed to a Diesel Stripper for removal of light gases (hydrocarbons, H_2S, H_2) and sent to the fuel gas system. The diesel product will then be sent to tanks for storage and blending, while the naphtha removed will be routed to the NHT along with the naphtha from the GRU.

Fuel Oil

Fuel oil from the CDU will be split into two streams: one will be routed to the existing Asphalt Unit for asphalt production via the existing fuel gas fired heater; the other will be fed via a new fuel oil fired heater to a new Vacuum Unit and separated into atmospheric gas oil (AGO), vacuum gas oil (VGO) and vacuum tower bottoms. AGO will be combined with the diesel feed to the Diesel Hydrotreater while VGO will be sent directly to storage tanks.

Vacuum Tower Bottoms

Vacuum tower bottoms (VTB) will be fed to a Delayed Coking Unit (DCU) via a fuel gas fired heater. In the DCU, the VTB is converted into lighter, more valuable products, namely LPG, naphtha, distillate and gas oil; products similar to those produced in the CDU. The residual petroleum coke (petcoke) will be sold as a by-product, which can be used to generate electricity in a similar fashion to coal.

Gases lighter than LPG which are produced in the DCU will be routed to the refinery fuel gas system along with those from the main GRU.

The LPG will be routed through a separate Gas Recovery Unit dedicated to DCU LPG, then to their respective storage vessels.

The naphtha and distillate will be combined with the feed to the DHT.

The coker gas oil (CGO) will be blended with the VGO and routed to storage.

The petcoke will be stored in stockpiles.

Sulphur Recovery

All light hydrocarbon gases destined for the fuel gas system will first be passed through an Amine Absorber in which an aqueous solution of Methyl Diethanol Amine (MDEA) will be used to absorb H_2S, CO_2 and mercaptans from the gases. Consequently SO_2 emissions from fired heaters will be substantially reduced. The MDEA, rich in acid gas, will then be fed to an Amine Regenerator (distillation tower) where the acid gases will be removed from the MDEA stream. The resultant acid gas (rich with H_2S) will be routed to the Sulphur Recovery Unit (SRU), while the MDEA will be recycled to the amine absorber.

Sour water streams (water with high H_2S and ammonia content) will be collected in a tank and fed to a Sour Water Stripping Unit which will use steam to remove the impurities. Stripped water will then be recycled for process use, for example in the Desalter. The acid gas produced will be combined with the acid gases from the Amine Absorber and fed to the SRU.

The SRU will consist of two (2) Sulphur Recovery trains utilizing the Claus Process, whereby a catalytic converter will be used to recover elemental sulphur from the acid gases. The solid sulphur will be sold as a by-product, while the tail gas produced will be fed to a Tail Gas Treating Unit (TGTU). In the TGTU, the tail gas from the SRU will first be heated in a fired heater, then passed through a reactor then finally contacted with MDEA, thus removing most of the sulphur which remained in the tail gas from the SRU in the form of elemental sulphur. The treated gas will then be incinerated in a boiler and the MDEA regenerated.

Waste Water Treatment

Waste water will first enter an oil water separator then undergo additional treatment, possibly consisting of a dissolved air flotation system, as is used in many refineries worldwide. The exact configuration is unknown at this time; however, all waste water will undergo the requisite treatment to meet the national effluent standards prior to disposal.

Utilities

All primary utility systems as listed below will be upgraded to meet the demands of the upgraded refinery.

- Boiler facilities will be upgraded to satisfy the increased steam demand.
- Additional Cooling Towers will be installed.
- The fuel gas system will be upgraded to satisfy the increased demand arising from the installation of new fired heaters.
- The existing flare will be replaced with one of larger capacity. Flaring is an environmentally acceptable method for safe disposal of refinery waste gases.
- An acid gas flare will also be installed to safely dispose of waste gases with high H2S content.
- Additional Reverse Osmosis Plants for treatment of well water will be installed. The feed water will be extracted from new wells, the locations of which are being determined through a comprehensive geological survey so as to minimize the potential environmental impact.
- Additional compressors will be installed to supply the required instrument and utility air.
- The upgraded refinery will also see the installation of a hydrogen production plant using steam methane reforming (SMR) and pressure swing absorption (PSA) technology, and also a nitrogen production plant using PSA technology.
- Electricity and steam will be purchased from the neighbouring JPS plant from a newly installed Cogeneration unit. The arrangement will be one of synergy, as Petrojam will

supply JPS with the petcoke which will be used for the generation of electricity and steam. Petrojam will in turn return the condensate to JPS.

2.2.1 Financial Comparison of Options

When the net present values (NPV) of three options were evaluated (see Table 2-1), the terminalling option was the least attractive. It should also be noted that various options for the upgrade were also considered and the selected upgrade option was the most attractive.

Table 2-1 Comparison of the Net Present Values of Options

Option	NPV @12% (US $Million)
Do Nothing	126.5
Terminalling	52.2
Upgrade Option (Case 12)	184.8

3 PUBLIC CONSULTATION PROGRAMME

The main public consultation entails two public meetings – one at the outset of the EIA and another towards the end of the EIA process. Additional components of the public consultation program are included in the socio-economic assessment task. The public meetings are described in this section together with a list of the additional consultation activities. Details of these additional activities, namely, other consultations with stakeholders are described in Section 4.14.

3.1 INITIAL PUBLIC MEETING

A public meeting to present and discuss the Terms of Reference for the Petrojam Refinery Upgrade EIA was held at Garmex HEART Institute on May 31, 2008. Notices for the meeting were posted in newspapers, fliers were posted in prominent places in the community and a Town Crier was employed to alert residents and business in the study area about the meetings. The meeting included presentations that described the nature of the upgrade of the plant and how the EIA would be conducted. This was then followed by a question and answer session:

While the purpose of the meeting was to obtain feedback on the TOR, it was an early indication of the socioeconomic issues that would surface in the community and stakeholder consultations. The main issues raised were:

- The skill level of persons residing in surrounding communities. It was felt that the skill levels in the communities were low and would not qualify for employment. It was also felt that those who were skilled had still not attained the level required. This would limit the potential for employment benefits to the communities.
- Uneven community development. This was related to the fact that there are successful industries/businesses in the area along Marcus Garvey Drive but their success is not reflected in the socioeconomic development in the adjacent communities. The perception was that the community should be developed in tandem with the industries/businesses.
- Partnerships. There was a call for greater partnerships between the communities and business to further development.
- Fishing. The comments indicated that commercial fishing was an important economic activity in the study area.
- The lack of communication about emergency response to the communities.
- The impact of Petrojam's sandblasting activities on nearby communities.

The meeting was attended by over 100 persons.

3.2 OTHER PUBLIC CONSULTATION ACTIVITIES

The social impact assessment also entailed consultation with community members and stakeholders through formal meetings and face to face interviews and the conduct of surveys (questionnaires were administered).

Formal meetings were held with the following communities:

- Tivoli Gardens Community (July 26, 2008) (20 attendees)
- Greenwich Town Community (July 31, 2008) (16 attendees)
- Rose Town Community members (August 7, 2008) (28 attendees)
- Whitfield Town Community members (October 2, 2008) (32 attendees)

At these meetings, Petrojam staff was also present and gave a presentation that described the project after which there was a general discussion during which questions asked were answered. These meetings were held because it was felt that there was insufficient attendance at the initial public meeting held on May 31.

After these meetings, interviews were conducted to help ascertain socioeconomic characteristics of the area and perception of the proposed project. Similar interviews were held with fisherfolk at the Greenwich Town Fishing Beach on July 26. Twenty one persons agreed to participate in the survey.

The social impact assessment also entailed consultation with stakeholders through face to face meetings and the conduct of surveys (questionnaires were administered). Written requests were made of the ten businesses located along Marcus Garvey Drive closest to Petrojam as well as NGOs with known interests in organizations.

There was response from one business located on Marcus Garvey Drive, six NGOs and one government organization. The outcomes of the stakeholder meetings are described in Section 4.14.

3.3 FINAL PUBLIC MEETING

The final Public Meeting will be held after the submission of this EIA to the governing body, the National Environment and Planning Agency. The public will be given at least three (3) weeks' notice before the date of the public meeting. In addition at least three (3) notices will be placed in the most widely circulated newspapers advertising the event.

4 DESCRIPTION OF THE EXISTING ENVIRONMENT - BASELINE STUDIES

4.1 PHYSICAL ENVIRONMENT

The Petrojam site is centred on UTM 307570mE, 1988400mN (see Figure 4-1). The site is bound by Marcus Garvey Drive and Shoemaker Gully to the north and northeast respectively. The Caribbean Sea (Kingston Harbour) borders the other sides of the property. The land slopes imperceptibly toward the sea with ground elevations range from 0.5 – 5 m above sea level (asl) increasing toward Marcus Garvey Drive.

4.1.1 Geology and Soils

Published geological information (Geological Sheet 25, 1:50,000 Imperial Series, extract shown in Figure 4-2 indicates that the entire site is Made Ground. Made Ground is solid ground made from other materials, usually engineering materials, but can consist of non-engineered fill. The site is classified as engineering fill.

The Water Resources Authority (WRA) classifies the geology of the site as an Alluvium Aquifer suitable for industrial uses only.

The Kingston Metropolitan Area Seismic Hazard Assessment: Final Report (1999) describes the reclaimed soils beneath the site as comprising engineered fill using data obtained from the Urban Development Corporation (UDC) and geotechnical reports dating back to the 1950's. These reclaimed areas are shown in Figure 4-3.

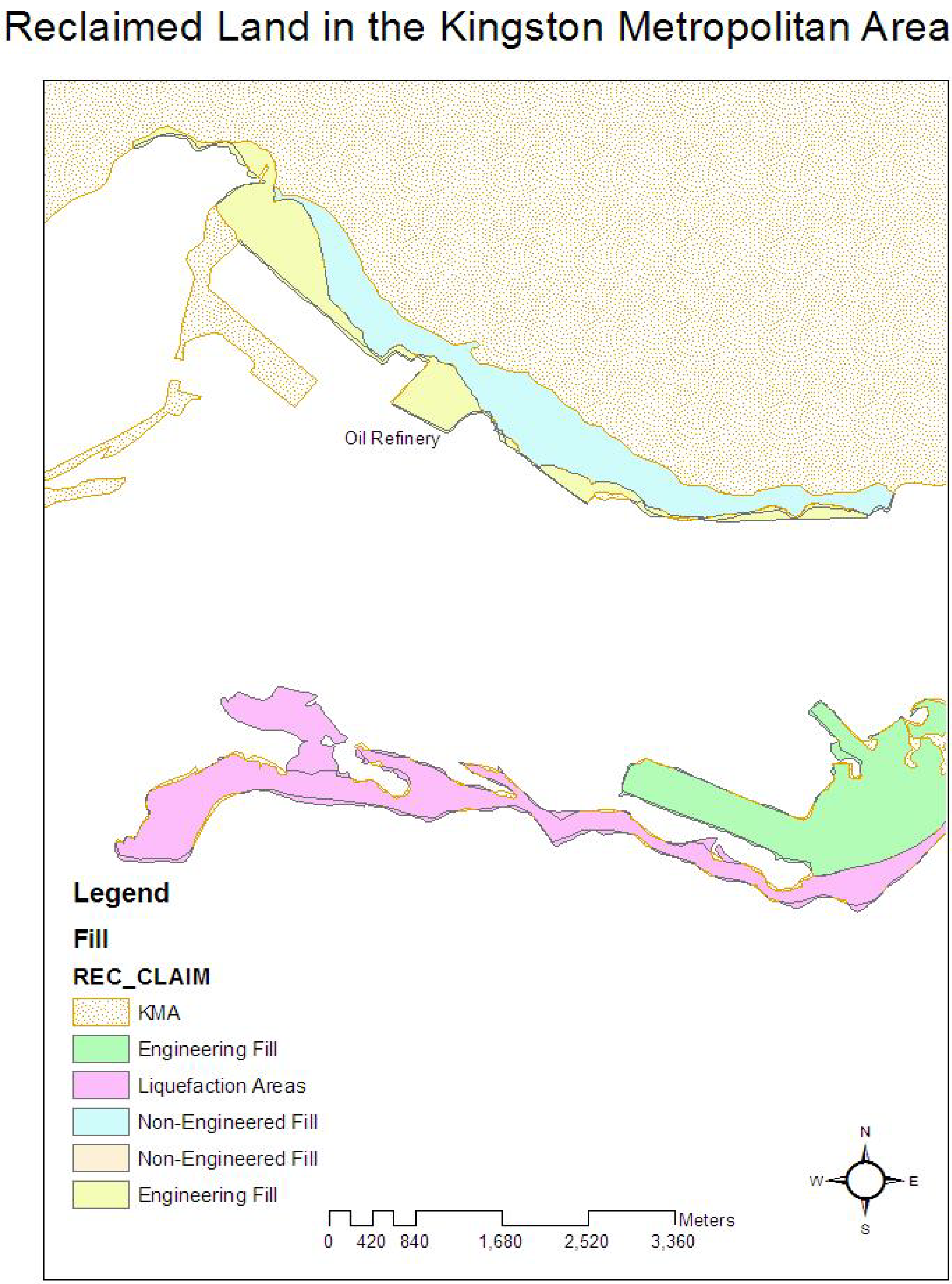
The engineered fill is composed of 2.4 to 7 m of thick hydraulic fill consisting of fine to medium sand and gravel with a trace of shell fragments. The fill was consolidated using conventional compaction techniques available in the 1950's and surcharge. Periodic borehole and probe tests were done to determine the final bearing strength of the hydraulic fill for design and construction. Soil conditions underlying the engineered fill consist of from 1.5 to 6 meters of organic silt, fine sand and varying proportions of decayed vegetation (soft, compressible soil). Figure 4-3 also shows the general location of the pre-1950 coastline which is generally defined by the boundary between the engineered and non-engineered fill. The composition of the non-engineered fill is generally more variable and generally consists of from 1 to 3 meters of loose to uncompacted sands, gravel, construction rubble (brick and concrete), organic material, and cinder/ash. With the underlying soils varying from highly compressible organic silt and loose fine sand, soft clayey soil, marl and limestone chips.

Figure 4-1 Site Location (adapted from Google Earth)

Pushpin marks approximate centre of site

Figure 4-2 Excerpt of Geological Map (Sheet 25) Showing the Petrojam refinery (shaded yellow) as Made Ground

Figure 4-3 Locations of Engineered Fill and Non-engineered Fill in the KMA



Source: KMA Seismic Hazard Assessment, 1999

4.1.1.1 Seismic Hazard

The seismic hazard map (Figure 4-4) of Kingston (Caribbean Disaster Mitigation Project, 2001) shows that the project site lies in an area that can expect significant peak ground acceleration (>45% of gravity) during an earthquake with a 479 year return period. The site's susceptibility to liquefaction and ground failure during moderate sized earthquakes makes it susceptible to damage and loss of life and consequent economic disruption.

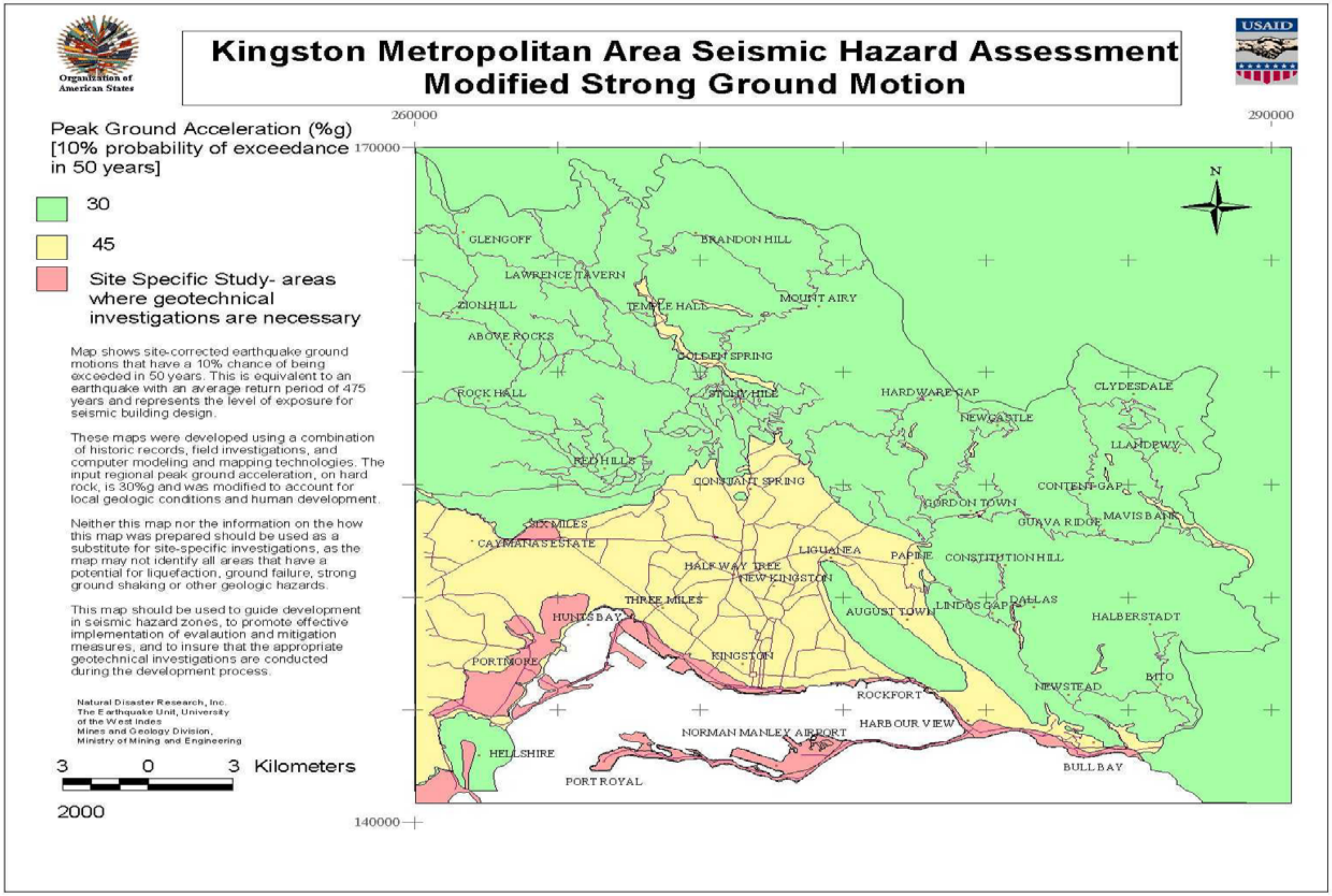
Since the upgrade processing area will be built on engineered ground it will perform better than those built on fill and unconsolidated soils. Many of the original structures were built over 40 years ago but in any event few of the original structures will be retained after the upgrade. For those structures that will be retained any necessary retrofits will be undertaken based on updated ground motion determined by the KMA study and by the design of the upgrade.

The current pipelines are fitted with manual shutoff values to reduce the likelihood of release of hydrocarbons to soil or water during earthquake (or other) events. All of the existing tanks are constructed with berms to accommodate and contain tank contents in order to prevent spills that may result from seismic (or other) events from spreading beyond the berms.

4.1.1.2 Landslip Hazard

The topography and geology suggest that land slippage would be a negligible risk. And any created slopes would need to be done according to the geotechnical design specifications to mitigate the risk of failure.

Figure 4-4 KMA Seismic Hazard Map for Strong Ground Motion



Taken from the Kingston Metropolitan Area Seismic Hazard Assessment (1999)

4.1.2 Water Resources

Surface Water

There are approximately 22 perennial rivers and gullies discharging into Kingston Harbour. Data on flow from these sources is scarce, but available information is discussed below.

Gullies

Fifteen major storm drains (paved gullies) discharge to the Kingston Harbour. Twelve of these discharge directly to the harbour while three discharge to Hunts Bay. Also discharging to Hunts Bay are the Rio Cobre, Fresh, and Duhaney Rivers. The Tivoli and Shoemaker gullies and Whitfield Town gully discharge just east and west of the Petrojam outfall respectively. Some of these gullies were natural drainage courses prior to being developed with concrete hardstanding to control and alleviate the annual flooding of these natural water ways.

There is limited information on the quality of water from these gullies but it is known that they function as receiving waterways for industrial waste and sewage from a number of sites in the corporate area. In addition, during heavy rains vast quantities of debris, solid, and liquid waste are known to be transported by these gullies to Kingston Harbour. Rio Cobre is also known to receive substantial amounts of industrial waste and sewage. Rio Cobre is also heavily impacted by silt and debris during periods of heavy rain.

Literature data (Wilson-Kelly, 1998) for mean concentrations for a number of key parameters for wet (high flow), and dry (low flow) periods are dated but are summarised in Table 4-1.

Table 4-1 Mean Concentrations (mg/l) of Selected Water Quality Parameters in Gullies Discharging to Kingston Harbour (1994 - 1995)

Parameter	Annual Mean Concentration	
	Wet	Dry
Total Suspended Solids	0 .10	0 .09
o-Phosphate	1.10	0.86
Nitrate	8.82	3.65
Biochemical Oxygen Demand	769	156

The nearest, named surface watercourse to the site is the Shoemaker Gully, which lies along the north eastern boundary of the site. The Shoemaker Gully is one of the many larger gullies that make up the larger Kingston's flood drainage network. Petrojam has no record of overtopping of the gully during heavy, sustained rainfall. The gully has flow only during sustained heavy rainfall events.

Ground Water

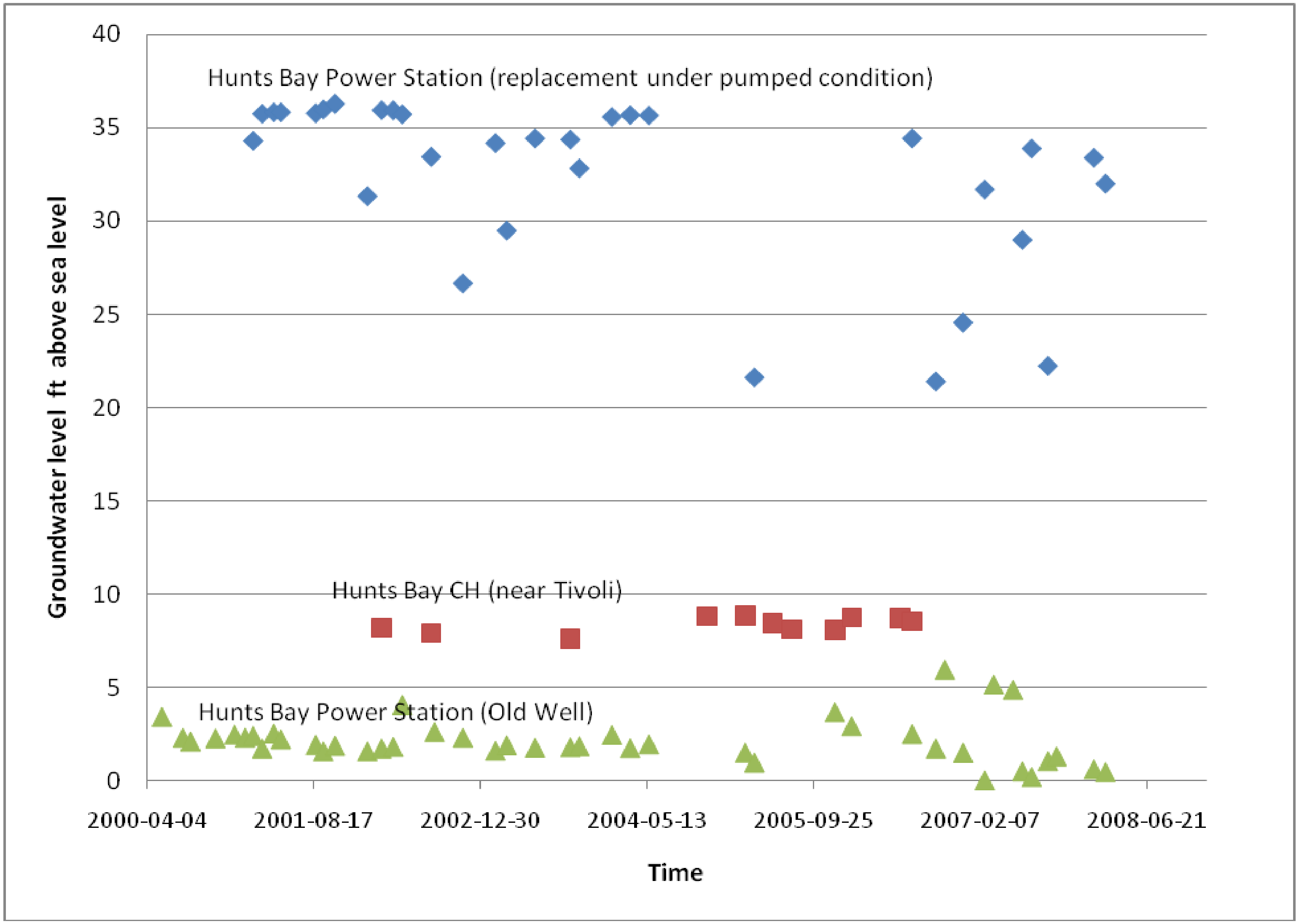
The refinery is located at the coastal section of the Liguanea alluvium aquifer, one of three aquifers on the Kingston Basin. The area of the Liguanea alluvium aquifer is about 75 km^2 and consists of a mixture of sedimentary gravels and clays. The aquifer has an annual yield of 32 Mm^3 with a reliable yield of 20.9 Mm^3. The 30-yr mean annual (1951-1980) rainfall for Kingston and St. Andrew was obtained from the Meteorological Office and is recorded at 56 mm and 103 mm for March and April 2008 respectively.

A significant amount of the groundwater in the aquifer is not suitable for drinking due to extensive nitrate contamination. It was estimated in 1985 that more than 40% of the aquifer was contaminated by sewage nitrate, and since that time a number of public supply wells on the alluvium aquifer have been abandoned (WRA, 1990). Groundwater vulnerability according to Groundwater Pollution Vulnerability Map (Sheet 18 by the WRA) is noted as high. This is based on the shallow depth to groundwater and the moderate attenuating capacity of the underlying unsaturated soils. Except along the coast, there is no water quality limitation for use as an irrigation or industrial source. Saline groundwater occurs naturally in some sections of the aquifer along the coast and industries utilising groundwater in these areas generally treat the water by reverse osmosis (RO).

Below the refinery the rocks consist of silty clay, silty sand with gravel and clayey silt. This is regarded as possessing low transmissivity and permeability. The alluvium at the site consists of an upper aquifer that is unconfined and a lower aquifer that is confined. The well on the site is located on reclaimed land, at approximately 2 m above sea level and is designed to abstract water from the lower, confined aquifer. There are 18.3 m of plain casing on the well to minimise pumping from the upper section of the aquifer thus ensuring higher biological quality for the RO plant, and to prevent dewatering of the upper section of the aquifer which could lead to surface subsidence. Since the well is located south or down gradient (hydraulic) of all other wells in the area, and as the water is to be abstracted from a confined section of the aquifer, interference with other wells is not a concern. Most wells sunk within close proximity to the site are used solely for industrial purposes and are not for human consumption without significant treatment.

Groundwater levels recorded in the Hunts Bay well (Figure 4-5) average about 2 m bgl (7ft bgl) in the old well and is considered to be the best representation of static groundwater level beneath the site in 1996. This corresponds generally well with the exploratory boreholes in 2007 that struck groundwater at a depth of 5m (16 ft) below ground level (bgl) (16ft bgl). Groundwater at depth will be

Figure 4-5 Groundwater Hydrograph of the Hunts Bay Well (Old and New)



Data points obtained from the WRA 2008.

artesian as the recharge waters are sourced from the higher elevations of Kingston and are confined by the layers of clay at depth.

Figure 4-6 shows all wells and licensed abstractions within the 2km of the site. The nearest licensed abstraction is Petrojam Plant No.1 well completed in June 1996 to a depth of 33.5m (110 ft). A licence to operate the well has been approved by the Water Resources Authority and the licensed abstraction rate is noted at 1470 m^3/d (270 gallons per minute (gpm)). Mains water for the Petrojam site is currently supplied by the National Water Commission.

The most recent site investigation within the site boundary was done in May and June of 2007 when 5 exploratory boreholes were advanced to determine the subsurface lithological profile and its suitability to accommodate a high yield industrial well. The indicated geology is summarized in Table 4-2. Other soil investigations have been performed in previous years, but borehole logs were not available for review. Generally those wells were advanced to characterize hydrocarbon contamination around the tank farms. Groundwater was met generally at 4.9 m (16ft) below ground level (bgl) and is artesian at depth. Some of the results of these investigations will be discussed briefly in the following section.

4.1.2.1 Sewage Treatment Facilities

There are no large functional municipal sewage treatment facilities within 2 km of the site. The commissioning of the Soapberry Treatment Works has resulted in the conversion of the Tivoli Gardens Sewage Treatment plant to a lift Station that routes sewage to the treatment works via another lift Station at Nanse Pen in the vicinity of the Sandy Gully Bridge on Spanish Town Road).

4.1.2.2 Flooding

No flooding, outside of localized areas of standing water is noted by Petrojam. The WRA has no record of any significant flooding event within the site. However, a high potential for liquefaction is noted at the site and generally within all the reclaimed areas (see Figure 4-6). Given the proximity of the site to the coast, shallow depth to groundwater and the low-lying nature of the land, flooding from rainfall events is a potential hazard. This is addressed further in the drainage assessment (see section 4.1.2.4.2).

Figure 4-6 Environmental Setting 2km from Petrojam#

The red crosses indicate groundwater wells known to the WRA. The blue teardrops indicate current licensed industrial groundwater abstractions. The red teardrops indicate areas of high liquefaction potential. The major roads are yellow lines and minor roads by white lines.

Table 4-2 Lithological Summary of the Exploratory Boreholes Advanced at Petrojam in May/June 2007

Exploratory BH1	Exploratory BH2	Exploratory BH3	Exploratory BH4	Exploratory BH5
0 – 22ft: Brown Clay and sand with heavy hydrocarbon contamination. 22 – 56ft: Brown clay /w sand and gravel lenses. 56 – 60ft: Coarse sand and gravel lenses. 60 – 100ft: Interbedded clay with fine sand and gravel.	0 – 14ft: Carbonate sand with clay layers. 14 – 30ft: Brown clay with fine sand 30 – 72ft: Gravel lenses /with interbedded clay and sand. 72 – 100ft: Brown clay with sand /with occasional lenses of sand and gravel.	0 – 12ft: Sandy loam with hydrocarbon contamination 12 – 30ft: Brown clay and fine sand. 30 – 72ft: Brown clay with coarse gravel lenses and fine sand. 72 – 100ft: Brown clay with fine sand.	0 – 20ft: Sandy, pebbly soil /w clay. 20 – 36ft: Gravel and coarse sand with clay. 36 – 60ft: Gravel and coarse sand /w a 12ft layer of clay at 42ft. 60 – 100ft: Clay interbedded with fine sand and gravel.	0 – 20ft: Loam /w pebbles and hydrocarbon contamination. 20 – 36ft: Clay and pebbles. 36 – 54ft: Coarse sand and gravel, interbedded with clay. 54 – 100ft: Brown clay with fine sand. 10ft gravel layer at 70ft bgl.

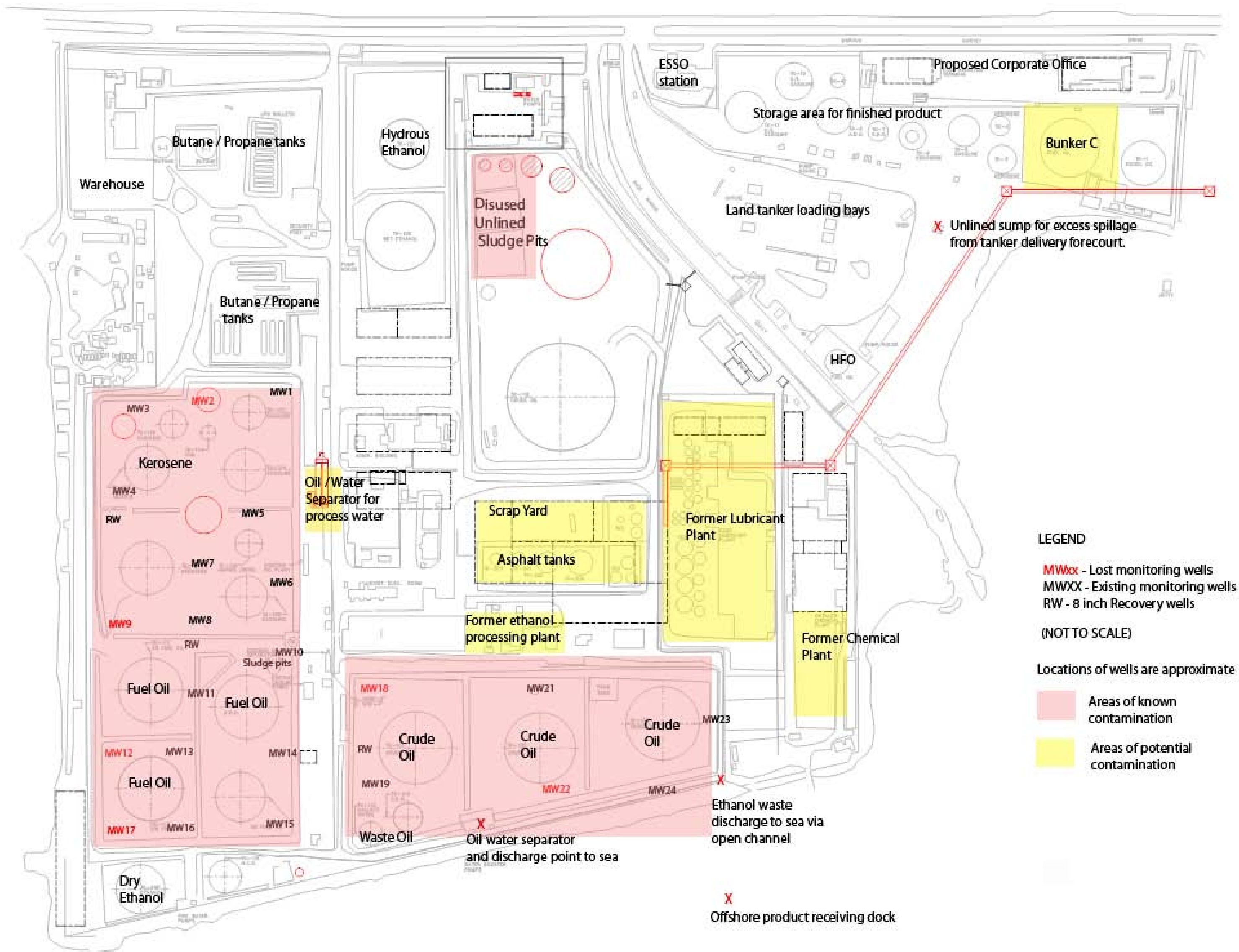
4.1.2.3 Groundwater Contamination By Hydrocarbon Spills or Leaks on Site

Petrojam has incomplete records between 2006 and dating back to 1990 that have been monitoring (by sinking monitoring and recovery wells) the hydrocarbon contamination beneath the tank farms.

A study undertaken in November 2006 documented the locations of monitoring and recovery wells around the western and south-eastern tank farms. The study showed significant thicknesses of hydrocarbon product in the subsurface beneath these tank farms.

Subsequently additional monitoring boreholes (now 24 in total) and three 8 inch recovery wells were distributed around the two tank farms. They were specifically targeted at known or suspected leaking tanks and areas of oil sludge disposal pits. A crude and conservative estimate suggests over 4.1 x 10^6 L (1 million gallons) of free product may exist beneath the site. This is based on the known contaminated areas (Figure 4-7) and assuming a 5 cm (2 inch) layer of free product

Figure 4-7 Locations of Known and Potential Hydrocarbon Contamination to Soil and Water (Not To Scale)



Petrojam has an ongoing program to recover product from the subsurface by periodically pumping the recovery wells. In addition an impermeable barrier along the western boundary of the facility has been installed.

Since one of the historical sources of contamination was sludge pits, Petrojam has discontinued placing sludge in the sludge pits. Instead, sludge it is separated into water, solids and oil by centrifuging. The oil is returned to the process, water to the API separator and solids are stored in drums on the site. Table 4-3 summarises the Petrojam results from the western tank farm and Table 4-4 summarizes the findings in the south-eastern tank farm. From the data it is clear that the tanks farms leaked and discharged to the soil and groundwater. Analyses of the recovered product indicate the following:

At MW8: Kerosene mixed with gasoline. MW8 is close to a kerosene storage tank (TK-109).

At MW10: Mainly diesel. MW8 is adjacent to a diesel storage tank (TK–110).

At MW19: A mix of diesel and heavy fuel oil.

Oil Spills

Between March 2003 and March 2006 no ship oil spill incident in Kingston Harbour was reported (Ministry of Transport and Works, 2008). In October 2004 during Hurricane Ivan the refinery lost power hence the pumps which would normally pump oil from the separator to the designated tank, did not perform. This resulted in oil reaching Kingston Harbour. The oil was cleaned up by Petrojam staff.

There have been minor spills associated with coupling of hoses at the marine dock between 2005 and 2008. Because of the small amounts it was not feasible or necessary to conduct any clean up exercises. Additional information on these spills and spills to land and other non-injury related incidents are presented in Section 4.1.9.

Table 4-3 Floating Oil Product Thickness (In Inches) From The Monitoring Wells In The Western Tank Farm

Well # ——→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TEST DATE 4/09/07	0	n/a	0	14 3/4	4	10	18	30 1/2	n/a	131/4	21/2	n/a	11/2	0	n/a	10	n/a
TEST DATE 30/4/07	0	n/a	0	2	2 1/4	1 3/4	4 1/2	13 3/8	n/a	9 1/2	4 7/8	n/a	0	0	0	5 3/4	n/a
TEST DATE29/12/06	0	n/a	0	2	3	3	3 1/2	13 1/2	n/a	11	3 1/2	n/a	0	1/4	0	5 3/4	n/a
TEST DATE 23/11/06	0	n/a	0	1 3/4	2 1/2	3	3 3/4	15	n/a	10 1/4	2 1/2	n/a	0	2/8	1/8	5 1/4	n/a
TEST DATE 15/10/06	0	n/a	0	2	3 1/3	6	5	10 1/2	n/a	11	2 3/4	n/a	0	1/2	3/8	8 1/4	n/a
TEST DATE 18/1/06	0	n/a	0	7/8	4 7/8	4 5/8	2 1/8	4 1/2	n/a	9 1/4	4 3/4	n/a	0	2 3/4	1 1/4	6	n/a

Source: Petrojam

Numbers in red are for wells for which data are not available

Table 4-4 Floating Oil Product Thickness (In Inches) From the Monitoring Wells In the South-Eastern Tank Farm

Well # ⟶	19	21	23	18,22 & 24
TEST DATE 4/9/07	201/2	0	2	Cannot be found
TEST DATE 30/4/07	13 1/2	0	1 1/4	Cannot be found
T. DATE 29/12/06	11 1/2	1/2	2	Cannot be found
T. DATE 23/11/06	9 1/4	2	3 1/2	Cannot be found
T. DATE 15/10/06	9	2 1/2	2 3/4	Cannot be found

Source: Petrojam data

Numbers in red are for wells for which data are not available

4.1.2.4 Hydrological Assessment

4.1.2.4.1 Existing and Projected Water Demand

Petrojam currently has a WRA license to abstract 1475 m^3/day (270 gpm) for industrial purposes. The WRA's main concern with abstraction from coastal aquifers is saltwater intrusion (Pers. Commun., 2008). Saltwater intrusion is the induced flow of seawater into freshwater aquifers caused by groundwater development near the coast. Where groundwater is being pumped from aquifers that are in hydraulic connection with the sea, induced gradients may cause the migration of salt water from the sea toward a well.

The projected water demand of 94.6 litres/s (1500 gpm) is just above the licensed abstraction rate of the existing production groundwater well. A licence to drill an additional well will be sought to provide a suitable buffer to meet any increased demand and to manage the abstraction of water from the aquifer. The additional abstraction can be readily be met by the Liguanea Aquifer once well placement, well design and in-operation pumping conditions are managed to work in equilibrium with the natural environment. This can be achieved by multiple wells or infiltration galleries to reduce drawdown which reduces saltwater up-coning.

4.1.2.4.2 Drainage Assessment

The drainage assessment will describe the current drainage facilities at the site and determine how these facilities handle routine operations (especially with regard to the separation of storm water and process wastewater streams and the effluent from the wastewater treatment plant) and an assessment of the ability of the site to handle storm water runoff.

The site is served by a system of storm water drains and a separate system of process drains.

In addition to surface water runoff, the storm water drains also receive cooling tower and boiler blowdown and rejects from the reverse osmosis (RO) plant.

Runoff from the refinery processing area is captured by an underground oily water sewer system which, along with aqueous process waste streams, is directed to the API separator. The aqueous process waste streams consist of water from crude and from process streams such as wastewater from caustic wash of the crude charge, spent caustic from the LPG stripping stream and steam heaters.

The refinery site includes the ethanol plant (Petrojam Ethanol Ltd.) which has a separate process drain that directs wastes from the ethanol plant to the sea.

The drains that direct water from the site to the sea are as follows:

- API separator drain
- Ethanol plant drain
- Stormwater drain

Details on the locations of these drains and water quality in the harbour near the outfalls for these drains are provided in the section on water quality (Section 4.1.4).

There is a major drain at the northern boundary of the property, paralleling Marcus Garvey Drive. Surface runoff generated north of the site is captured by this drain and diverted to the sea. Surface runoff along Marcus Garvey Drive does not enter the property, except possibly under extreme rainfall conditions.

To perform the drainage assessment the Rational Method was used and site land use evaluated from photographs and site walkover. The latter indicated that a majority if not all of the site is covered in some type of hard-surfacing, ranging from compacted earth to asphaltic concrete and Portland cement concrete plus building. The rainfall intensities used for the calculation were taken from the Norman Manley International Airport rainfall IDF curves (Intensity-Duration-Frequency curves) – see Table 4-5.

Table 4-5 Rainfall intensities from the Western Terminal (1950-87) provided by the Metrological Service of Jamaica

Exceedance Probability	100% (1 yr return)	50% (2 yr return)	20% (5 yr return)	10% (10 yr return)	4% (25 yr return)	2% (50 yr return)	1% (100 yr return)
24-hr rainfall (mm)	-	110	158	203	259	302	344

4.1.2.5 Site Storm Water Runoff

The site is completely developed, and was constructed from reclaimed lands using engineered fill. The site is approximately 36 hectares (ha) and is extensively industrialized with large areas of hard surfacing comprising buildings, storage tanks and roads. The open areas are likely to be heavily compacted ground. Based on this the site can be classified as principally hardstanding with a high runoff potential.

For the existing facility, the drainage assessment will look at the current runoff flows (which are expected to be similar or equivalent after the upgrade) and their potential impact on the aqueous environment.

To perform the evaluation the Rational Method was used and site land use evaluated from photographs and site walkover. The latter indicated that a majority if not all of the site is covered in some type of hard-surfacing, ranging from compacted earth to asphaltic concrete and Portland cement concrete plus building. The rainfall intensities used for the calculation were taken from the Norman Manley International Airport rainfall IDF curves (Intensity-Duration-Frequency curves) – see Table 4-6. The calculations for the Rational Method are presented in Table 4-7.

Table 4-6 Predicted Run-Off Estimates (Existing Facility)

Site Area	Site Runoff with a 10% exceedance probability
Pre-development (predicted existing)	4.3 m^3/s

Table 4-7 Runoff Calculations for the Petrojam Plant for a 1 in 10yr Event

Project: Petrojam Refinery Expansion
Location: Kingston
Client: TEMN

Date: July 2008

Rational Equation

Q=0.00278 CIA	Metric units		
Q=1.008 CIA	SI units		
Where,		Explanation	
Q = peak runoff rate (cfs, m^3/s)			
C = runoff Coefficient from Table in Sheet 2	0.9	Industrial Area runoff co-efficient for FAA method	unitless
I = average rainfall intensity (in/hr, mm/hr)	47	FAA method calculated time of concentration (t_c)	mm/hr
A = the drainage area (acres, hectares)	36	Site drainage area	hectares

Pre-development	**10 year return**		
C	0.9		unitless
I	47.0		mm/hr
A.	36		hectares
Conversion factor	0.00278		
Calculated Peak Discharge, Q	4.26		m^3/s
TOTAL	4.3	m^3/s	

Post-development	**10 year return**		
C	0.9		unitless
I	47.0		mm/hr
A	36		hectares
Conversion factor	0.00278		
Calculated Peak Discharge, Q	4.27		m^3/s
TOTAL	4.3	m^3/s	

Percentage change 0%

4.1.3 Storm Surge Analysis

A storm surge analysis for the Petrojam facility involved a Hurricane Wave Hindcast Analysis to investigate the wave climate and storm surge in the vicinity of the Petrojam Refinery during extreme conditions. Details of the storm surge analysis are provided in the Appendix (Section 9.3).

The site is located east of Port Bustamante, within Hunt's Bay, Kingston Harbour (Figure 4-8 and Figure 4-9). The site is protected by the Palisadoes strip from regular and hurricane-generated wave action in the open sea to and is mostly vulnerable to waves generated inside Kingston Harbour during extreme events.

The occurrence of storm surges is difficult to predict based on short-term analysis, but the accuracy of predictions can be markedly improved by taking into consideration the history of occurrences of hurricanes over a long period of time. The method of using past storm and hurricane occurrences to predict the intensities of future ones is called hindcasting.

An in-house computer program, HurWave, was used for hindcasting for this project. The program includes a complete database of all storms and hurricanes occurring in the North Atlantic and the Caribbean from 1900 to present and water depths (bathymetry) for the site. The bathymetry was generated from existing data collected for previous investigations done within Kingston Harbour.

Using data from the tracks of each tropical storm or hurricane, HurWave selected storm events that passed within a 300 km radius of the Petrojam Refinery site. For each event, the significant wave height, peak wave period, maximum wind speed and corresponding central pressure were determined for a series of points along the track. Probabilistic analysis was then done to determine the 50 and 100-year storm conditions and the associated exceedance probability.

Figure 4-10 shows a directional distribution of the estimated wave heights for all hurricanes in the database from 1900. This shows that storm waves approach predominantly from the east. This is because of the typical west-north-westerly tracks of the hurricanes and the anticlockwise rotating wind field that characterizes these cyclones. The south coast of Jamaica typically is exposed to the waves in the bottom right quadrant of the approaching hurricanes.

Because of the location and general nature of the site, only waves approaching from the southerly sectors are able to enter directly into Hunt's Bay. However waves generated by easterly winds inside Kingston Harbour can have an impact on the project site.

Figure 4-8 Kingston Harbour with the Petrojam Refinery Highlighted (Google Earth)

Figure 4-9 A Closer View of the Petrojam Refinery Site (Google Earth)

An extreme value statistical analysis was carried out to calculate the significant wave height, peak wave period and wind speeds that are characteristic of different hurricane return periods. The analysis took into account waves approaching from offshore in deep water (water depths greater than 200m) and coming from all the eastern to southern directions. Similar to the wave directional plot in Figure 4-10 the critical wave heights were shown to be coming from the east and east-south-east (details are provided in the Appendix [Section9-3]). From this directional analysis of the hurricane waves, it is seen that those waves coming from the east have had the greatest wave heights, followed by those coming from the south-east. Waves from the more southerly directions, however, are expected to have a greater impact on wave conditions inside the Kingston Harbour, as they are better able to directly enter the harbour.

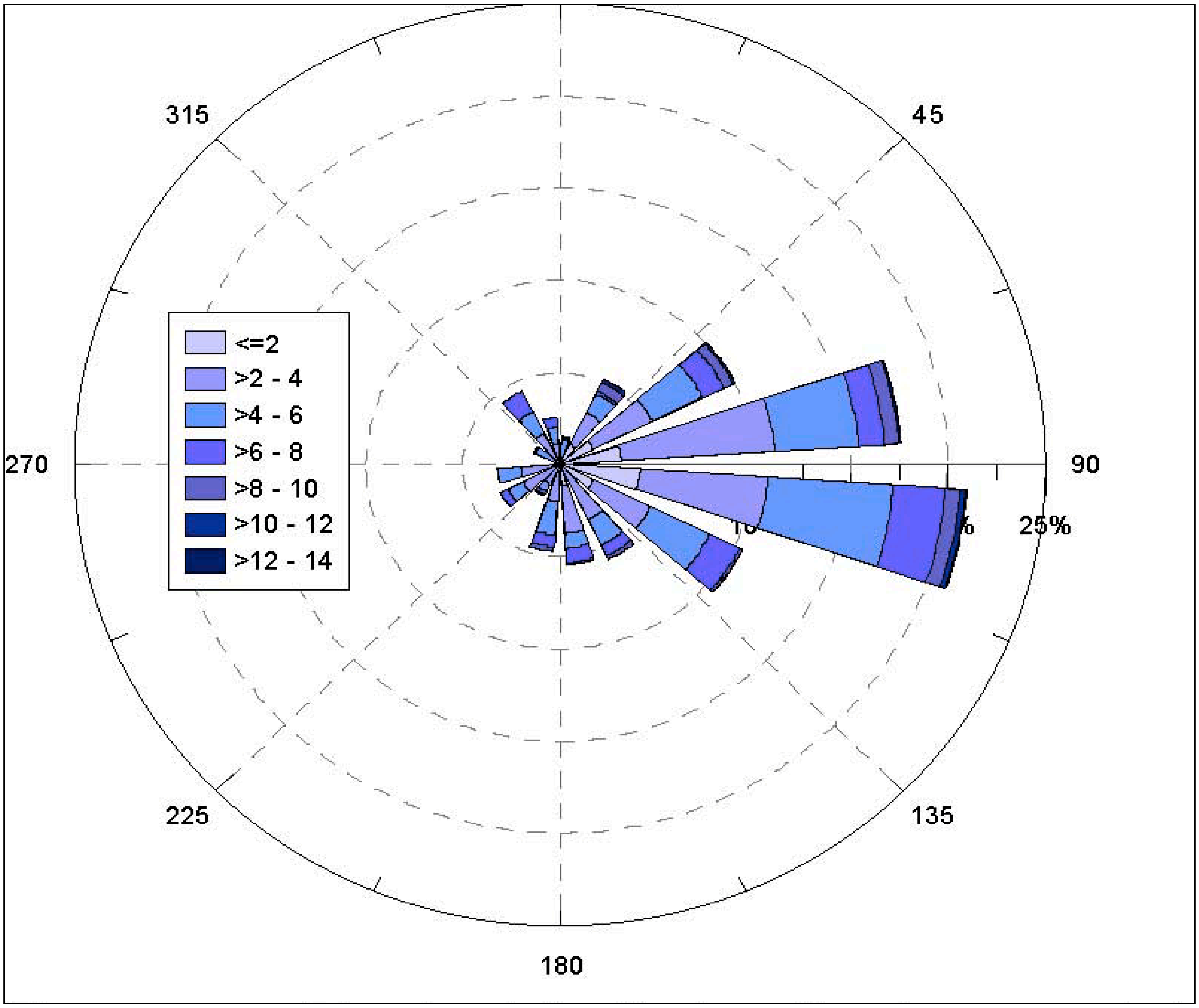
The HurWave model is able to determine storm surge and wave conditions in deep water (greater than 200 m depth). At shallower depths such as in Kingston Harbour a more detailed model is required and the SWAN (Simulating Waves in Near-shore Areas, Delft Institute of Technology, The Netherlands) model was used.

For the model to run effectively, all wave input boundaries have to start at depths greater than 200m in order to simulate the waves approaching the shoreline from deepwater. This meant that the model had to be run on an extensive area to include the shallow water outside of Kingston Harbour extending beyond the cays to the edge of the offshore reefs. The model was run individually for each of the seven directions taken into consideration in order to reach the worst-case scenario in terms of wave height and storm surge.

Overall, the greatest wave heights and static surge values were generated for the East-Southeast direction but deep water waves are not able to penetrate into the harbour; instead the waves affecting the project area are generated inside Kingston Harbour by intense East-Southeast winds.

Deep-water waves coming from the southwest quadrant were able to enter the harbour but they did not produce significant wave heights and storm surge values at the site. This is due to the presence of cays just outside the harbour and very shallow areas inside the harbour, which dissipate the energy of the waves before they approach the vicinity of the Petrojam Refinery.

Figure 4-10 Directional Distribution of Hurricane Wave Heights (m) Off Kingston Harbour



Summary of Results

Tables 4-8 and 4-9 illustrate the results for the computed maximum significant wave height and static storm surge at three locations around the Petrojam Refinery for a number of return periods.

The East-Southeast direction had the maximum wave heights for all of the return periods examined. The largest wave height values were 1.3 m for the 1-in-100 year event while that of the 1-in-25 year return period was 0.5 m.

The greatest possible inundation level that can be experienced at the site is 1.73 m for the 1 in 100 year return period event from the ESE direction. The SSW and SW directions had values of 1.32 m and 1.38 m respectively for the same return period (see Table 4-8).

Table 4-8 Summary of Significant Wave Heights

Eastern point, P1			Southern point, P2		Western point, P3	
Direction	Return Period (years)	Hs (m)	Return Period (years)	Hs (m)	Return Period (years)	Hs (m)
ESE	25	1.11	25	1.04	25	0.47
ESE	50	1.23	50	1.18	50	0.56
ESE	100	1.31	100	1.31	100	0.71
SSW	100	1.02	100	1.09	100	0.86
SW	100	1.01	100	1.06	100	0.74

Table 4-9 Storm Surge Summary Statistics for Eastern Section of the Petrojam Refinery

Direction	Return Period (years)	Static Storm Surge (m)
ESE	25	1.49
ESE	50	1.62
ESE	100	1.73
SSW	100	1.32
SW	100	1.38

4.1.4 Water Quality

Baseline information on water quality is required to identify and quantify actual and/or potential future influences on water quality in the vicinity of the refinery. Trade effluent from the refinery is discharged into Kingston Harbour by way of three outfalls and hence establishment of baseline coastal water quality is imperative. The main outfall is that from the wastewater treatment plant/API separator while of a smaller outfall is that from the ethanol dehydration plant which is located within the Petrojam property. The third outfall is from the storm water drain which includes boiler blow-down and reject water from the reverse osmosis plant. The main outfall is submerged and access for sample collection is via a sump located just outside the perimeter fence along the southern boundary.

Six (6) sampling sites were established to monitor water quality in Kingston Harbour near the outfalls (4 sites) and at a background site in the outer Harbour. The sixth monitoring site was the main outfall itself. Coordinates for sampling sites are presented in Table 4-10 and are illustrated in Figures 4-11 and 4-12.

Table 4-10 Petrojam Upgrade EIA Water Quality Sampling Sites

Site ID	DESCRIPTION	Latitude (°N)	Longitude (°W)	Zone 18 UTM N (m)	Zone 18 UTM E (m)
PJKH1	Background (Rackham's Cay)	17.92610	76.83932	1982972.3	305176.5
PJKH4	East of Petrojam Outfalls	17.97097	76.81557	1987913.8	307741.3
PJKH3	Over Separator Outfall	17.97327	76.81982	1988172.8	307293.7
PJKH4	The Point Where Ethanol Plant Effluent Enters Sea	17.97197	76.81725	1988032.8	307569.8
PJKH5	The Point Where Storm Drain/Boiler Blow Down Enters Sea	17.97329	76.81966	1988174.9	307310.6
PJKH6	Separator Effluent-Sump	17.97339	76.81970	1988186.0	307306.5

Figure 4-11 Petrojam Upgrade EIA: Water Quality Sampling Station No. 1, Background - Rackham's Cay

See Table 4-9 for Site ID

Figure 4-12 Petrojam Upgrade EIA: Water Quality Sampling Stations No. 2 - 6, Kingston Harbour

See Table 4-9 for Site ID

Based on a review of the list of chemicals used in the process and on typical components in refinery effluent streams it was determined that two of the parameters for which there are NRCA Trade Effluent standards could be omitted or sampled less intensely. These included chromium and coliform. This is because the refinery has ceased the use of chromium compounds in the cooling water circuit and all domestic sewage generated on the site is discharged to the NWC sewer. The pollutants that were monitored in the samples and the corresponding NRCA Trade Effluent Standards (limits) and World Bank standards are presented in Table 4-11 while US EPA ambient standards for marine waters are presented in Table 4-12.

Samples were analysed in accordance with APHA, AWWA, Standard Methods for the Analysis of Water and Wastewater 20th Edition as well as Hach methodology. Dissolved oxygen, pH, turbidity and salinity were determined using portable instrumentation. A summary of the analytical methods used is given in Table 4-13.

Table 4-11 NRCA Standards for Selected Pollutants in Trade Effluent

Parameters	**NEPA Standard Limit [1]**	**World Bank Limit [2]**
Total Nitrogen	10 mg/L (as NO_3)	10 mg/L
Phosphate as o-$(PO_4)^{3-}$	5.0 mg/L	
BOD_5	< 30 mg/L	30 mg/L
DO	> 4 mg/L	
TSS	<150 mg/L	30 mg/L
TDS	1000 mg/L	
Total Coliform	< 500 MPN/ 100ml	
Faecal Coliform	<100 MPN/ 100ml	
Oil and grease	10 mg/L	10 mg/L
pH	6.5 – 8.5	6 - 9
Temperature (°C)	2 °C +/- of ambient	≤ 3 °C
Phenols	5 mg/L	0.5 mg/L
Sulphide S^{--}	0.2 mg/L	1 mg/L
Chromium	1.0 mg/L	0.5 mg/L
COD	< 100 mg/L	150 mg/L
Benzene		0.05 mg/L
Benzo(a)pyrene		0.05 mg/L
Cr^{+6}		0.1 mg/L

MPN – Most probable number

[1] Draft Natural Resources Conservation Authority (Wastewater and Sludge) Regulations 2005 (http://www.nepa.gov.jm/regulations/Natural%20Resources%20Conservation%20_Wastewater%20and%20Sludge_%20Regs%20July%202005.pdf)

[2] World Bank Pollution Prevention and Abatement Handbook, 1998

Table 4-12 Ambient Standards for Marine Waters*

Parameter	**Draft Standard**
Nitrogen as NO_3	0.001 -0.081 mg/L
Phosphorous as o-PO_4	0.001-0.055 mg/L
BOD	0.57-1.16 mg/L
Dissolved Oxygen	4.8 mg/L*
Suspended Solids	< 10mg/L***
Total Coliform	48-256 MPN/100 ml
Faecal Coliform	<200 MPN/100 ml

*Source: USEPA Water Quality Criteria September 1999)
***Proposed Coral Reef Criteria Value – (Draft NRCA Coral Reef Policy)

Table 4-13 Analytical Methods Used To Determine Water Quality Parameters

Parameter	**Method**	**Detection Limit/range**
Nitrate (NO_3)	Colorimetric Cd reduction Hach 8192 3rd Ed.	0.04 mg/L
o-Phosphate (o-PO_4)	Colorimetric Hach 8048 2nd Ed.	0.01 mg/L
BOD	Bottle method/titrimetry Standard Method 5210 B 20th Ed.	0.1
DO	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 - 19.9
Turbidity	U-10 Horiba Water Checker	0 - 800NTU
Coliform (Total/Faecal)	Multiple Tube Fermentation, Standard Method 9221 B-E 20^{th} Ed.	2MPN
Oil And Grease (Hexane extractable)	Gravimetric n-Hexane Extractable Method Hach 1056 3rd Ed.	1.0 mg/L
pH	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 - 14
Temperature	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 - 50^{o}C
Salinity	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 - 40ppt

Wastewater Characterisation

Wastewater characterisation was based mainly on recent data collected by Petrojam (between August 2007 and April 2008). This was supplemented by results from limited sampling carried out by the CDA/TEMN study team between June and July 2008. Wastewater characterisation focussed on effluent from the Separator (Station 6), comparing the levels of indicator parameters in individual samples to NRCA standards. Results are summarised in Table 4-14.

Levels for **suspended solids** and **chromium** were always below the corresponding standards while 93% of the pH measurements were within the range specified in the standard.

Temperature of the effluent from the separator was generally elevated being on average 47 ±12 ^{o}C with a maximum of 67 ^{o}C and a minimum of 30 ^{o}C. Of 36 measurements, 3 met the standard.

Oil in separator effluent for the monitoring period ranged from 12 mg/L to 2686 mg/L. The average was 362 ± 718 mg/L. All 26 measurements were higher than the standard.

The average **sulphide** level was 17.2±25.6 mg/L. Sulphide levels ranged from 0.8 mg/L to 129.8 mg/L. Of 22 measurements, none met the standard with 1 measurement being of the same order of magnitude.

Chemical oxygen demand was in the range 30 mg/L to 1641 mg/L. The average was 575±469 mg/L. Of 17 measurements, 1 was compliant. Of 3 **BOD** measurements made in June and July 2 did not meet the NRCA standard. The **BOD** levels were 8 mg/L, 39 mg/L and 103 mg/L.

Ambient Water Quality

Average concentrations of selected parameters in sea water samples collected are presented in Table 4-15.

Oil and Grease was in the range 3.5 mg/L to 6.9 mg/L (Figure 4-13). The lowest value was determined over the separator outfall (Station 3). The average value for oil and grease was 6.9 mg/L at the background site (Station 1) and 6.6 mg/L east of Petrojam (Station 2).

Temperature was in the range 29.1^{o}C to 29.9 ^{o}C (Figure 4-14). The slightly elevated value was determined for the station in the vicinity of the submerged separator outfall (Station 3). Though slightly higher than at the other sites, temperature in the vicinity of the outfall was within the standard for marine water.

Average **Dissolved Oxygen** was in the narrow range 5.5 mg/L to 5.8 mg/L (Figure 4-15). The higher DO values were in the vicinity of the Separator outfall (Station 3).

Table 4-14 Summary of Measurements of API Separator and Storm Drain Effluent (April 2007 to April 2008)

Parameter	Standard	Storm Drain Effluent				API Separator Effluent			
		Mean	Std Dev	No. of samples	No. >Std	Mean	Std Dev	No. of samples	No. >Std
Temperature (°C)	32	34	5	73	31	40	11	96	33
Conductivity (μmhos)	None	4439	7392	71	0	2887	2170	52	0
TDS (mg/L)	1000	3089	4471	67	0	2381	2127	49	0
TSS (mg/L)	150	2	5	65	0	4	4	49	0
Oil (ppm)	10	19	41	69	34	246	554	51	30
pH	6.0 – 9.5	8.4	1.1	72	23	8	1	52	1
$S^{=}$ (ppm)	0.2	3.5	12	62	56	11	19	46	29
DO (mg/L)	None	5.5	1.9	46		2	1	17	
COD (mg/L)	100	110	203	66	11	553	498	41	28
Cr	1.0	0.0005	0.0038	1	0	0	0	0	0
Phenol	0.1			0		4.3	13.1	9	8

Table 4-15 Mean and Standard Deviation (SD) Ambient Concentrations of Criteria Pollutants in Kingston Harbour

STATION ID	O/G (mg/L)		T (°C)		DO (mg/L)		BOD (mg/L)		NO3 (mg/L)		PO4 (mg/L)		FC (MPN/100ml)		TSS (mg/L)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. Background: Rackham's Cay	6.9	5.0	29.1	0.1	5.8	0.3	0.6	0.6	0.37	0.12	0.12	0.08	8	10	8.8	0.4
2. East Of Petrojam Outfall	6.6	3.1	29.6	0.1	5.8	0.3	1.8	1.8	0.95	0.91	0.32	0.35	111	97	17.6	9.4
3. Mixing Zone Over Separator Outfall	3.5	1.3	29.9	0.2	5.5	0.8	0.6	0.6	3.60	5.33	0.17	0.08	104	153	9.4	4.1
6. Separator Effluent	362	718	56.6	2.0	0.2	0.2	49.9	48.5	0.35	0.10	2.94	2.84	0	0	4.9	4.4
NRCA Standard	None		None		4.8		1.2		0.08		0.06		<200		10.0	

Values exceeding the NRCA standard are highlighted.

Figure 4-13 Oil & Grease Levels in Kingston Harbour

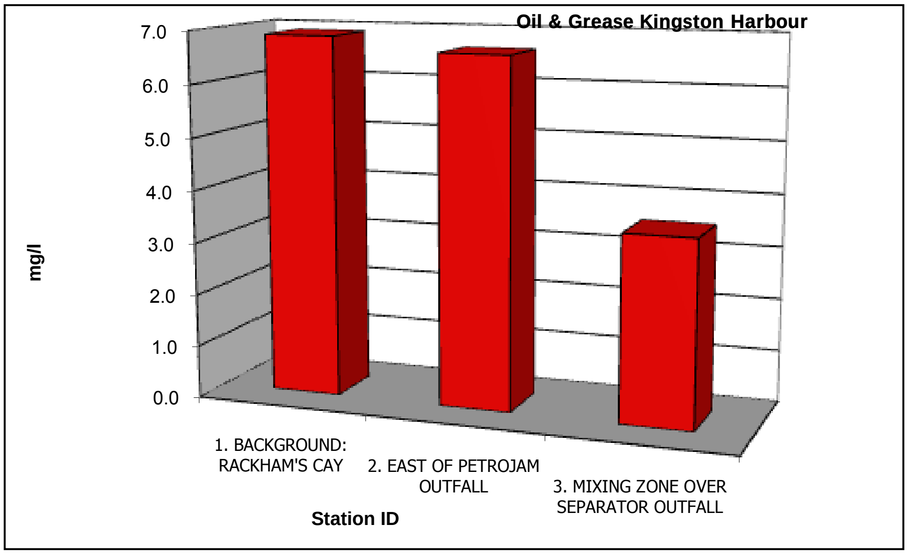


Figure 4-14 Temperature levels in Kingston Harbour

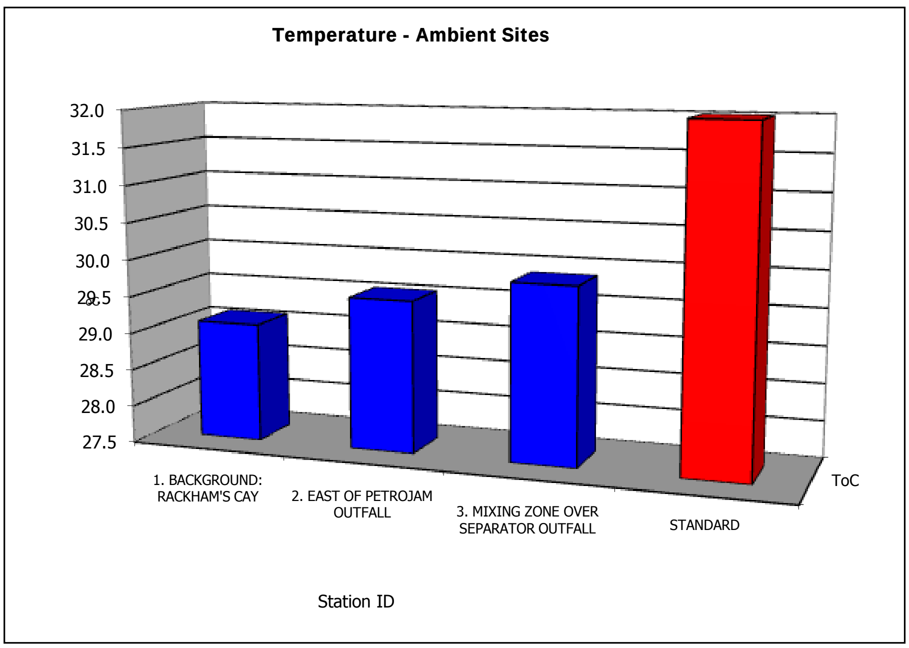
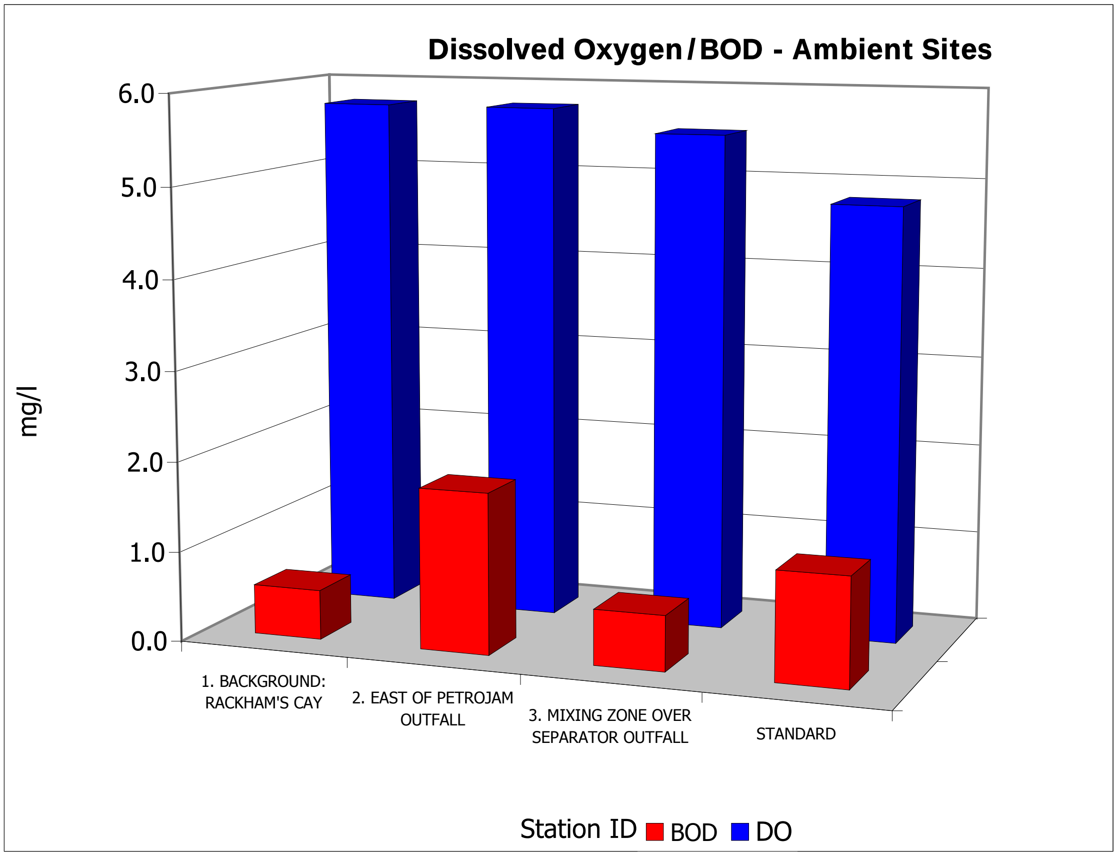


Figure 4-15 Dissolved Oxygen & BOD Levels in Kingston Harbour



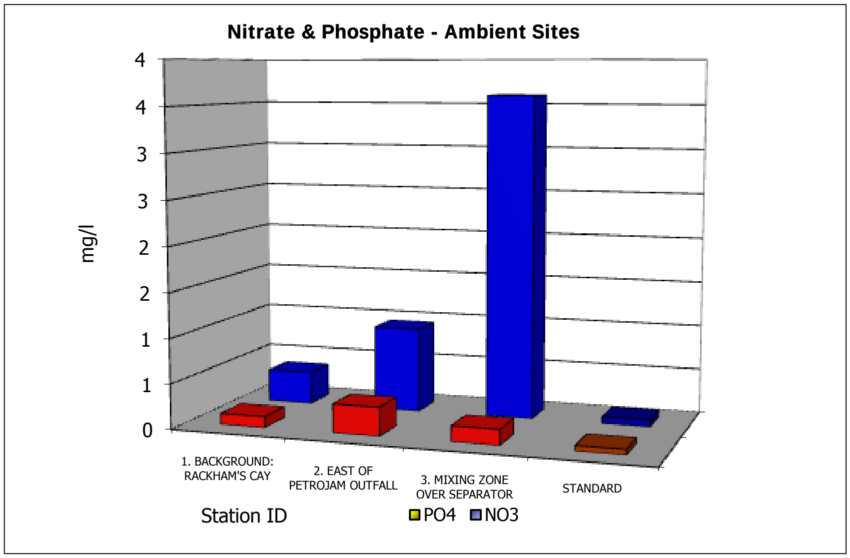
Average DO was the same at the background site and the site east of the refinery.

Biological Oxygen Demand (BOD) was in the range 0.6 mg/L to 1.8 mg/L (Figure 4-15). BOD was lowest at the background site and over the separator outfall (Figure 4-15).

Nitrate was in the range 0.37 to 3.60 mg/L (Figure 4-16). The lowest level was at the background site while the highest (3.60 mg/L) was at the site near the outfall (Station 3). East of the refinery (Station 2), nitrate was 0.95 mg/L.

Phosphate was in the range 0.12 mg/L to 0.32 mg/L (Figure 4-16). This exceeds the standard level of 0.06 mg/L. Phosphate was lowest at the background site (Station 1) and highest at the site east of the refinery (Station 2). At Station 3 phosphate was 0.17 mg/L.

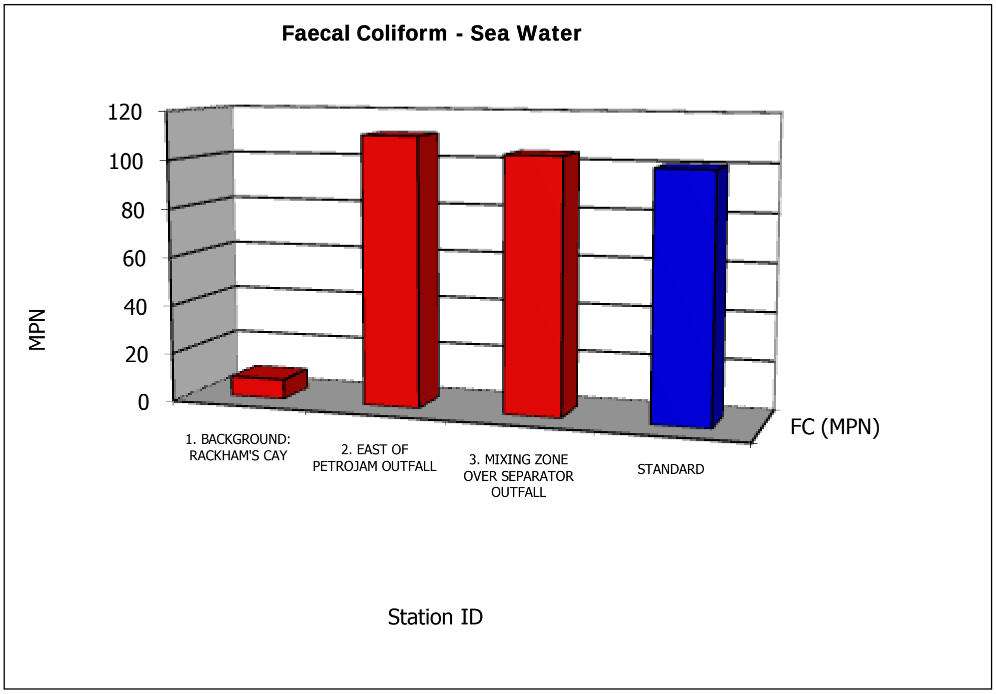
Figure 4-16 Nitrate & Phosphate Levels in Kingston Harbour



Faecal coliform at the harbour sites was significantly higher than the background site (Figure 4-17). At the background site (Station 1) faecal coliform was 8MPN/100ml, east of the refinery the level was 111 MPN/100ml and at the separator outfall the level was 104MPN/100ml.

Total Suspended Solids (TSS) was determined to be in the range 8.8 mg/L to 17.6 mg/L. TSS was highest east of the refinery (Station 2) while at the at the background site (Station 1) and near the outfall (Station 3) TSS was 8 mg/L and 9.4 mg/L.

Figure 4-17 Faecal Coliform Levels in Kingston Harbour



4.1.5 Climatic Conditions and Air Quality

4.1.5.1 Climatology

Since local and regional climatic conditions affect the dispersion of pollutants, an understanding of the prevailing long-term climatic patterns and the short term, site-specific meteorological conditions will help to assess the likely impact of refinery emissions on local air quality. A general overview of the climatology of the site is presented. The site is only ~6 km to the NNW of the meteorological station at Norman Manley International Airport (NMIA) and there are no intervening topographical features that would result in differences in meteorology between NMIA and the site. Meteorological data from NMIA will therefore be representative of the site and the NMIA data can be considered site-specific to Petrojam.

The monthly mean values for selected parameters for NMIA from 1951 to 1980 and for 1992 2001 are summarised in Tables 4-16 and 4-17 respectively. Wind data for the period 1981 to 1990 are summarised in Table 4-18 and the frequencies of wind directions and wind speeds are illustrated in Figure 4-18.

Table 4-16 Monthly Mean and Annual Mean Values for Selected Meteorological Parameters: Norman Manley International Airport 1951 – 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Mean
Maximum Temp. (^{o}C)	29.8	29.6	29.8	30.3	30.8	31.2	31.7	31.9	31.7	31.3	31.1	30.5	30.8
Minimum Temp. (^{o}C)	22.3	22.3	22.9	22.6	24.7	25.3	25.6	25.3	25.3	24.8	24.1	23.1	24
Rainfall (mm)	18	16	14	27	100	83	40	81	107	167	61	31	62.1
No. of raindays	4	4	3	5	5	6	4	6	8	10	6	4	5.4
Rel. Hum. - 7am (%)	80	78	77	77	76	73	76	76	78	80	79	78	77.3
Rel. Hum. - 1pm (%)	61	62	64	60	66	65	65	68	68	65	65	64	64.4
Sunshine (Hours.)	8.3	8.6	8.5	8.7	8.2	7.7	8.2	8	7.2	7.4	7.8	7.8	8

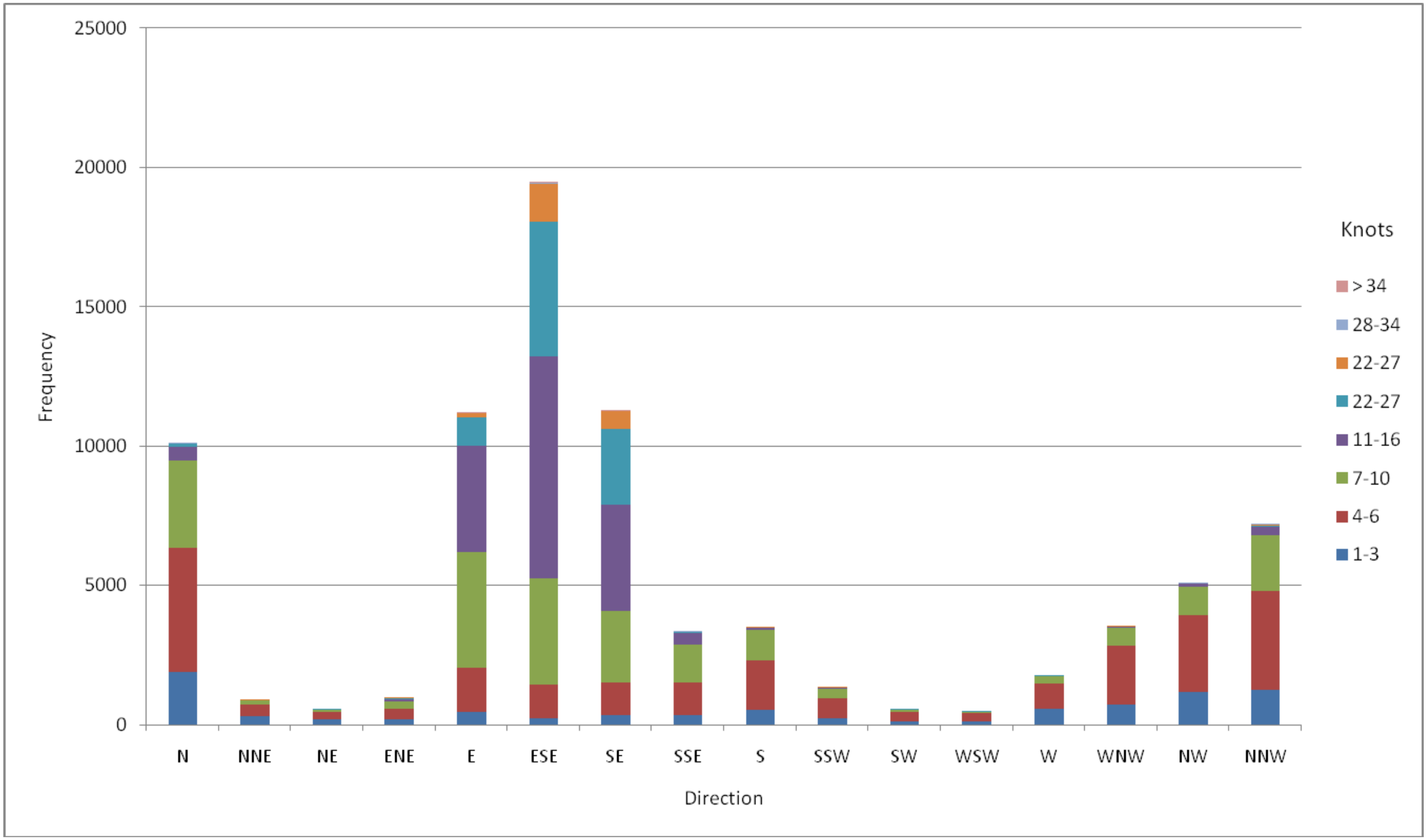
Table 4-17 Monthly Mean and Annual Mean Values for Selected Meteorological Parameters: Norman Manley International Airport 1992 – 2001

Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual Mean
Max Temp. (^oC)	31	30.9	31.1	31.7	32	32.8	33.4	33	32.8	32.4	32	31.4	32
Highest Max. (^oC)	32.8	32.7	32.6	33	33.6	34.4	35.1	34.9	34.7	34.3	34	33.2	33.8
Min Temp. (^oC)	22.6	22.6	23.1	23.9	24.9	26	25.8	25.6	25.5	25	24.2	23.2	24.4
Lowest Min. (^oC)	20.7	20.5	20.7	21.5	23.4	23.7	23.7	23.5	23.3	23	22.1	21.3	22.3
Mean Daily Temp (^oC)	26.8	26.7	27.1	27.8	28.5	29.5	29.6	29.3	29.2	28.7	28.1	27.3	28.2
Rainfall (mm)	29.7	25.7	22.3	24.3	73	51.2	31.7	63.8	147	103.5	120.6	40	61.1
No. of raindays	6	5	6	5	8	5	5	7	9	8	6	5	6.3
Rel. Hum. - 7am (%)	81	81	80	77	76	76	75	77	79	80	81	82	78.8
Rel. Hum. - 1pm (%)	63	64	63	63	67	65	63	67	68	68	66	63	65
Mean Sunshine (Hrs.)	8.3	8.4	8.5	9	8	8.2	8.2	8	7.4	7.7	7.5	7.8	8.1
Thunder (Days)	0	1	0	0	3	3	7	7	11	8	3	1	3.7
Evaporation (mm)	8.5	9	11.2	11.8	11.5	12.4	11.9	11.9	9.9	8.5	9.1	8.4	10.3

Table 4-18 Wind Speed and Direction Data: Norman Manley Airport 1981 – 1990

Wind Speed	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**N**	**All DIR**	**All DIR**	**Avg speed**
Knots	020 - 030	040 - 050	060 - 070	080-100	110-120	130-140	150-160	170-190	200-210	220-230	240-250	260-280	290-300	310-320	330-340	350-010		%	kt
0																	12792	14.72	0
1 – 3	102	47	61	151	66	60	85	143	88	84	64	290	556	644	798	438	3677	4.23	2
4 – 6	373	194	346	796	431	371	545	1035	457	297	281	697	1435	2253	3486	2104	15101	17.37	5
7 – 10	536	311	857	2470	1434	1027	1093	1429	578	279	216	545	866	1801	3787	3020	20249	23.29	8.5
11-16	169	121	868	5520	3675	1714	751	257	87	59	31	79	96	255	809	930	15421	17.74	13.5
17 - 21	35	14	265	3734	3322	1475	327	45	10	4	2	6	8	53	108	97	9505	10.93	19
22 - 27	15	0	59	2786	3254	1509	238	12	3	1	1	3	5	54	51	70	8061	9.27	24.5
28 - 33	7	0	8	594	520	224	19	7	1	0	1	0	5	24	31	52	1493	1.72	30.5
34 - 40	0	0	0	7	8	10	3	3	0	0	1	0	1	15	0	13	61	0.07	37
41 - 47	0	0	1	1	0	1	4	0	0	0	0	0	0	0	0	0	7	0.01	44
48 - 55	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	51.5
56 - 63	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	3	0	59.5
>63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	63
Frequency	1237	687	2465	16059	12710	6391	3068	2932	1224	724	597	1620	2972	5099	9072	6724	86373	100	
Missing %																		0.64	
Average Speed	18.54	19.09	18.29	14.8	13.67	14.32	17.74	19.46	19.16	18.11	18.03	16.99	16.59	17.54	18.54	18.89	13.94		

Figure 4-18 Wind Speed and Wind Direction Frequencies: Norman Manley International Airport, 1981 - 1990



Wind data at NMIA for 2007 are summarised in Table 4-19. The wind rose at NMIA for 2007 is shown in Figure 4-19 and wind speed classes for 2007 in Figure 4-20.

For the period from 1951 to 1980, the monthly mean maximum daily temperature ranges from 29.6 °C to 31.9 °C and the monthly mean minimum temperature ranges from 22.3 °C to 25.6 °C with highest temperatures in July and August. For the period from 1992 to 2001, the monthly mean maximum daily temperature ranges from 30.9 °C to 33.4 °C and the monthly mean minimum temperature ranges from 22.6 °C to 26.0 °C with highest temperatures in July and August There has been slight increase in both monthly mean maximum and minimum temperatures during the period of 1980 and 1992 as compared with the period of 1951 and 1980. The relatively narrow range in temperature reflects the moderating influence of the sea.

For the period from 1951 to 1980, the highest monthly average rainfall occurred between May and October and the annual mean rainfall is 62.1 mm. October has the highest average monthly rainfall (167 mm) and days with rain (10 days). For the period from 1992 to 2001, the highest monthly average rainfall occurred between September and November with May having a rainfall of 73.0 mm, August 63.8 mm showing a shift in rainfall patterns as compared with the period of 1951 and 1980; September has the highest average monthly rainfall (147 mm) and days with rain (9 days). The annual mean rainfall for this period is 61.1 mm as compared with the period between 1951 and 1980.

The main regional scale weather features that affect the island are upper level pressure troughs (an elongated area of low atmospheric pressure at high altitude), tropical waves and incipient storms and cold fronts. A tropical wave is a kink or bend in the normally straight flow of surface air in the tropics which forms a low pressure trough, or pressure boundary, and showers and thunderstorms. It can develop into a tropical cyclone. Upper level troughs occur year round but are more frequent in the winter when there are more frequent temperate latitude low pressure systems and fronts. The summer troughs are fewer but can be more persistent. The troughs sometimes interact with the easterly waves (a wavelike disturbance in the tropical easterly winds that usually moves from east to west) and tropical storms to produce intense rainfall. Tropical waves and incipient storms occur in the summer and move from east to west and are good rainfall producers. During winter months, cold fronts associated with low pressure systems that form over the south central United States can reach Jamaica although they are moderated by the still warm water in the Gulf of Mexico and the Caribbean. These fronts can be stationary and produce much rainfall over the northern areas of Jamaica.

Table 4-19 Wind Speed and Direction Data: Norman Manley Airport 2007

Direction/Wind Classes (Knots)	1-4	4-7	7-11	11-17	17-21	>=22	Total
348.75 - 11.25	125	156	320	217	11	12	841
11.25 - 33.75	107	122	220	133	8	11	601
33.75 - 56.25	53	50	77	39	9	42	270
56.25 - 78.75	51	38	69	96	25	73	352
78.75 - 101.25	38	38	104	252	102	196	730
101.25 - 123.75	36	30	107	310	213	690	1386
23.75 - 146.25	27	36	85	288	199	723	1358
146.25 - 168.75	26	15	63	122	49	128	403
168.75 - 191.25	30	31	86	103	9	10	269
191.25 - 213.75	15	33	74	51	1	1	175
213.75 - 236.25	18	20	54	24	1	0	117
236.25 - 258.75	25	20	27	6	0	0	78
258.75 - 281.25	42	26	25	5	1	0	99
281.25 - 303.75	52	74	89	26	2	0	243
303.75 - 326.25	114	129	213	61	6	0	523
326.25 - 348.75	142	173	362	164	4	1	846
Sub-Total:	901	991	1975	1897	640	1887	8291
Calms:							418
Missing/Incomplete:							51
Total:							8760
Frequency of calm wind	4.8%						
Average wind speed	14.17 knots						

Figure 4-19 Wind Speed and Wind Direction Frequencies: Norman Manley International Airport, 2007

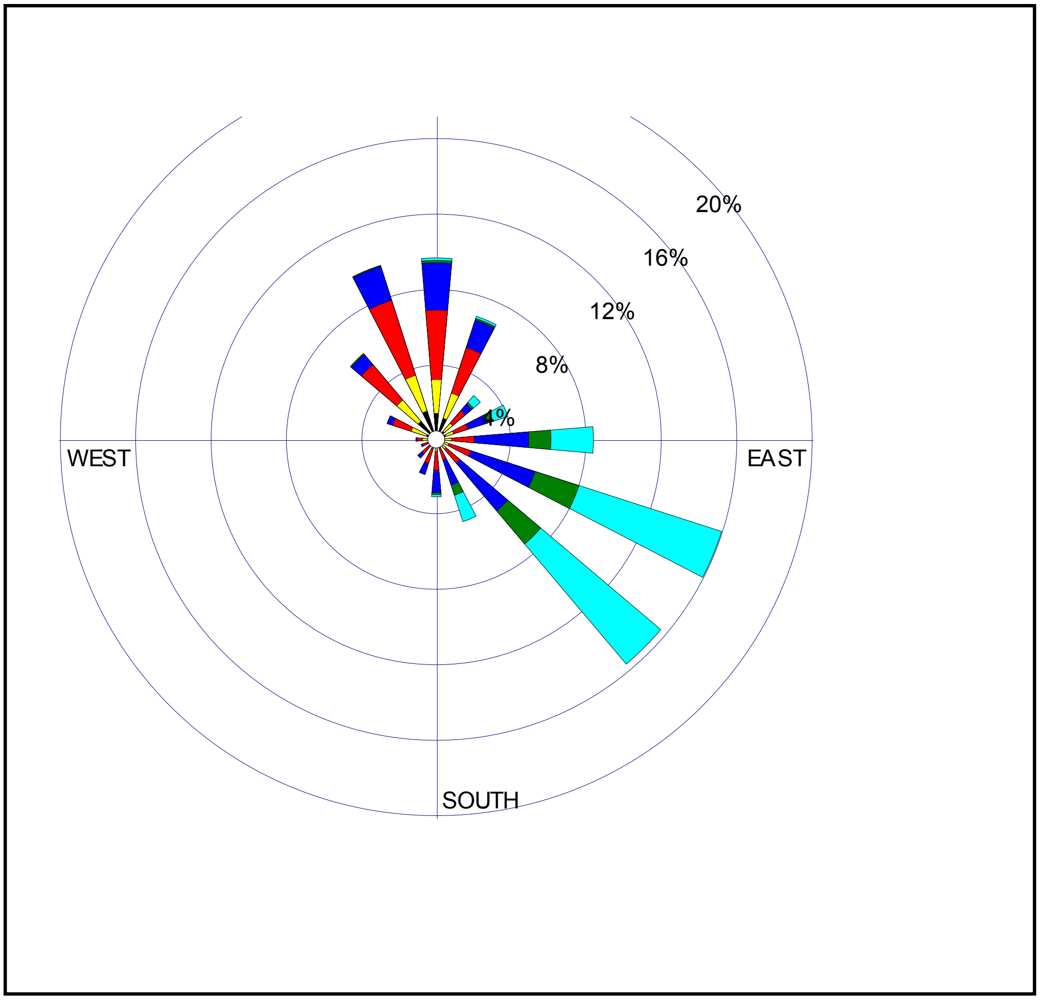
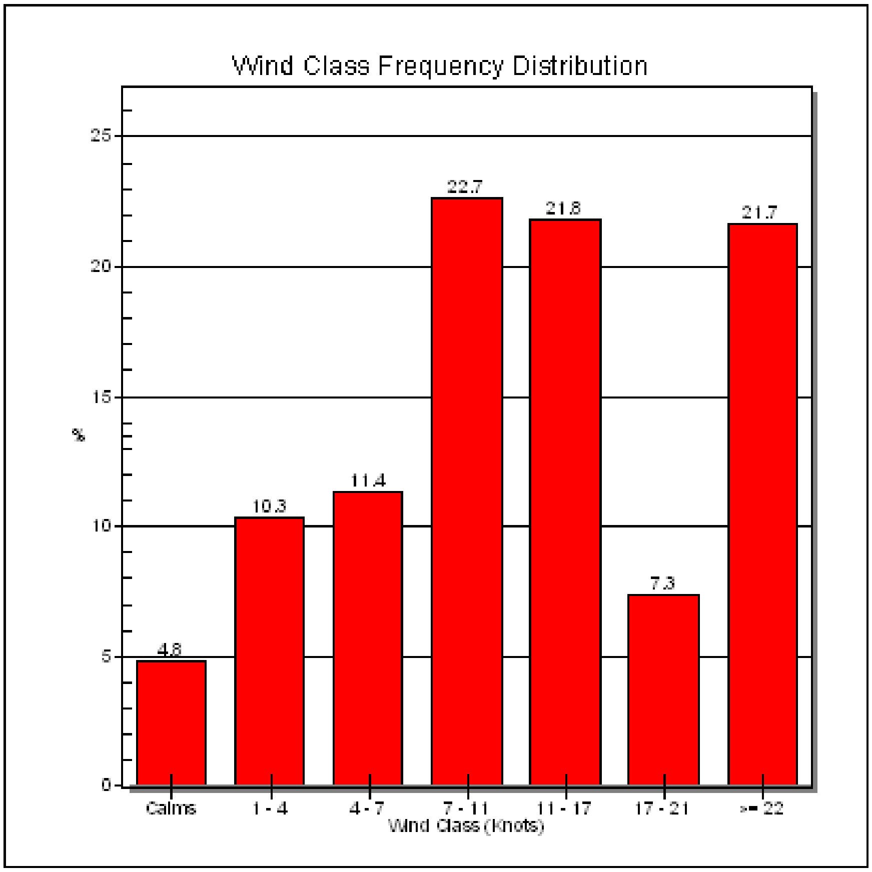


Figure 4-20 Wind Class Frequencies: Norman Manley International Airport, 2007



The dominant winds over Jamaica are the northeast trade winds whose strength is governed by the strength and location of the Azores-Bermuda sub-tropic high pressure cell. During the summer months the high pressure cell is weaker and farther north (than in winter) and consequently the trade winds are broad, persistent and extend further south. In the winter months, the central pressure of the cell is higher and further south and the winter trade winds are weaker and have a more northerly component.

The wind data for the period 1981 to 1990 shows that the most predominant wind directions (see Figure 4-18) are from the east-south-east, east and south-east. These are the prevailing sea-breeze directions and reflect the effects of the mountains which lie along an east-west axis. The mountains deflect the dominant north-easterly trade winds and provide the easterly component to the winds. Sea breeze influences provide a southerly component. Winds from the north-northwest and north are the other dominant direction and reflect land breeze as well as influences of cold fronts and the northeast trades. The mean wind speed over the period was 10.3 knots (19.1 km/h). Winds from the south had the highest wind speeds (19.5 knots (kt)) followed by the south south-west. Winds from the ESE had the lowest average wind speeds. Calm winds were reported 14.7% of the time and wind speeds of 1 to 3 kt were reported 4.2% of the time.

The wind data for 2007 (see Figure 4-20) also show the most predominant wind directions remain from east and east-south-easterly. The mean wind speed in 2007 was 14.17 knots (26.3 km/h) and calm winds were reported 4.8% of the time (see Figure 4-20).

4.1.6 Air Pollutant Sources in the Kingston Airshed

The Petrojam refinery is located in an area that is bounded by mountains that are 8 to 12 km away and which run in an anticlockwise direction from the east to the northwest. The sea is to the south and the area for at least 20 km to the northwest through southwest is flat land (St. Catherine Plains and Portmore). The mountains form a natural barrier to the prevailing east and east-southeast winds which carry emissions towards them. Night time land breezes will transport emissions in a southerly direction towards the sea. It is conceivable that, under some meteorological conditions in which a circulation pattern is established, the previous day's emissions (transported to the sea by land breeze at night) may re-enter the airshed blown by daytime sea breezes. The airshed and model domain are therefore defined as a 21 km by 20 km area with the refinery near the centre.

The major air pollution point sources in the Kingston airshed are summarised in Table 4-20 and 4-21. The existing Petrojam sources account for about 14.5% of SO_2 emissions, 1.2% of NOx emissions, 11.8% of particulate emissions, 0.2% of CO emissions and ~3.9% of VOC emissions from point sources.

Other air pollutant sources in the airshed consist of point sources (see Table 4-19) and area sources such as motor vehicles. The Jamaica Public Service Company's (JPS) Hunts Bay Generating station which is within 2 km of the Petrojam refinery, is the largest user of heavy fuel oil in the airshed, and accounts for 36.7% of the maximum licensed SO_2 emissions in the airshed. Hunts Bay also is also the major point source in the airshed for NO_2 (17.7%) and particulate (32.8%) emissions. Other major point sources are the Jamaica Private Power Company (JPPC) and JPS electricity generating stations at Rockfort and the Carib Cement Company Ltd. (CCCL) plant also at Rockfort. The remaining point sources are facilities with industrial boilers. All sources use up to 3% heavy fuel oil except for the JPPC plant which is permitted to burn up to 2.2% sulphur. The CCCL plant also burns coal for kiln heating.

Motor vehicles are the other major source of nitrogen oxides, carbon monoxide, particulate matter and volatile organic compounds. Estimates of SO_2, NOx, CO

Table 4-20 Characteristics for Kingston Airshed Point Sources

Description	SOURCE ID	Stack ID.	Zone 18 UTM E	Zone 18 UTM N	Base Elev.	Stack Height	Stack Temp.	Exit Velocity
			(m)	(m)	(m)	(m)	(Deg K)	(m/s)
Flare	FLARE	FLR	307340	1988244	1.5	45.72	1473	16232
Pipestill heater	F1	PJAMF-1	307496.4	1988255	4.2	45.72	699.8	4.19
Powerformer Feed preheater F-234	F234	PJAMF-234	307505.3	1988264	4	45.72	624.8	3.71
Vacuum furnace	F201	PJAMF201	307507.13	1988266.32	3.5	20.5	602.59	6.15
Nebraska (Oil)	NEBRSKA	NBRSKA	307522.5	1988224	3.5	20.5	602.59	6.15
New Cleaver Brooks Boiler (B1B)	NCLVBRB	CBB	307518.2	1988227	3.6	17.37	602.59	80.41
Hurst Boiler	HURST	PJAMF-1	307496.4	1988255	4.2	18.29	699.82	4.19
D&G Boiler Stack East	DG1	DG1	305922.7	1991542	11	45.72	533	12
D&G Boiler Stack West	DG3	DG3	305904.7	1991557	11	18	523	11.9
D&G Boiler Stack	DG2	DG2	305913.7	1991549	11	18	523	11.9
JPPC Engine 1	JPPC1	JPPC1	314376	1987692	7.4	65	672	45.9
JPPC Engine 2	JPPC2	JPPC1	314380	1987692	7.4	65	672	45.9
CCC Kiln 4 Dry 1300 tons/d	CCCLD	CCCLD	316680	1987152	20.4	44	433	12.8
CCC Kiln 3 Wet 700 tons/d	CCCLW	CC3	316542.6	1987325	71.4	44	433	9.4
JPS-Rockfort	JPSROCK	JPSROCK	314500	1987543	7.2	38.8	616	21.83
JPS-Rockfort	JPSROCK2	JPSR2	314500	1987554	7.2	38.8	616	21.83
JPS-Hunts Bay B6	JPSHBB6	JPHB6	308271	1987952	4	45.7	441	5.85
JPS Hunts Bay GT (GT10)	JPSHGT10	JPHGT10	308364	1987948	4	11.54	689	15.8
Jamaica Ethanol Processing Ltd.	JAETH1	Jeth 1	315203	1987788	17.7	6.103	358.71	10
Carib Products	CP1	CP1	305581.4	1991871	9	14.6	477	1
JPS Hunts Bay GT (A5)	JPSHBA5	JPHGTA5	308569	1988137	4.4	12.04	766	8.3
Clinker cooler 3	CCCLR3	CCLR3	316629	1987263	68.1	24.2	443	20.4
Clinker cooler 4	CCLR4	CCLR4	316637	1987289	72.28	24.4	478	20

Table 4-21 Kingston Airshed Point Source Emissions

Description	Source ID	Maximum Hourly Emission Rates					Annual Emission Rates				
		SO_2 (g/s)	NOx (g/s)	PM (g/s)	CO (g/s)	VOC (g/s)	SO_2 (t/y)	NOx (t/y)	PM (t/y)	CO (t/y)	VOC (t/y)
Petrojam Flare	FLR	0.315	0.0265	0.000133	0.00155	0.0132	8.94	0.75	0.00	0.04	0.38
Petrojam Pipestill heater	F1	45.8	5.28	3.280	0.456	0.009	1300	150	93.1	12.93	0.26
Petrojam Powerformer Feed preheater F-234	F234	13.93	1.17	0.0182	0.213	0.0170	395	33.2	0.517	6.03	0.48
Petrojam Vacuum furnace	F201	2.52	0.146	0.003	0.037	0.0029	71.5	4.15	0.089	1.04	0.08
Petrojam Nebraska (Oil)	NBRSKA	37.6	0.089	2.484	0.399	0.0078	1067	2.54	70.5	11.33	0.22
Petrojam New CB Boiler (B1B)	NCLVRBB	17.1	0.041	1.128	0.181	0.0035	485	1.15	32.0	5.14	0.10
Petrojam Hurst Boiler	F1	8.54	0.020	0.564	0.091	0.0018	242	0.576	16.0	2.57	0.05
D&G Boiler Stack East	DG1	9.81	0.979	0.610	0.104	0.002	278	27.8	17.3	2.96	0.06
D&G Boiler Stack West	DG3	6.85	0.683	0.547	0.073	0.001	194	19.4	15.5	2.06	0.04
D&G Boiler Stack	DG2	6.85	0.683	0.547	0.073	0.001	194	19.4	15.5	2.06	0.04
JPPC Engine 1	JPPC1	36.6	142.7	10.039	30.7	11.6	1039	4049	285	872	331
JPPC Engine 2	JPPC1	36.6	142.7	10.039	30.7	11.6	1039	4049	285	872	331
CCC Kiln 4 Dry 1300 tons/d	CCCLD	4.38	28.03	2.106	7.94		124	796	59.8	225	0.00
CCC Kiln 3 Wet 700 tons/d	CC3	42.23	38.11	2.369	0.06		1199	1082	67.2	1.70	0.00
JPS-Rockfort	JPSROCK	100.9	55.7	2.8	132.8	6.99	2864	1581	79.5	3769	198
JPS-Rockfort	JPSR2	117.3	47.1	2.9	132.8	6.99	3329	1337	82.3	3769	198
JPS-Hunts Bay B6	JPHB6	251.3	26.1	9.9	225.8	0.02	7132	741	281	6409	0.54
JPS Hunts Bay GT (GT10)	JPHGT10	18.2	38.34	3.35	1.5	0.00574	517	1088	95.1	42.6	0.163
Jamaica Ethanol Processing Ltd.	Jeth 1	15.03	1.50	0.720	0.160	0.002	427	42.6	20.4	4.53	0.06
Carib Products	CP1	7.85	0.0186	0.518	0.083	0.002	223	0.529	14.7	2.36	0.05
JPS Hunts Bay GT (A5)	JPHGTA5	27.5	25.36	2.22	0.9	8.82E-06	781	720	63.0	25.5	0.00
Clinker cooler 3	CCLR3	0	0	0.701	0		0.00	0	19.9	0.00	0.00
Clinker cooler 4	CCLR4	0	0	1.102	0		0.00	0.00	31.3	0.00	0.00
D&G Grain handling	DGV	0	0	0.720	0		0.00	0.00	20.4	0.00	0.00
Total		807	555	58.7	565	37.4	22,910	15,744	1,665	16,038	1,060
Petrojam		117	6.75	6.91	1.29	0.05	3,328	192	196	36.5	1.57
Petrojam% of Total Point Sources		14.5	1.2	11.8	0.2	0.14	14.5	1.2	11.8	0.2	0.15

and NMVOC emissions from motor vehicles (Davis *et. al.*, 2006) in the entire island for 2005 were respectively 4,200, 17,100, 28,200, and 41,100 tonnes. [Note that PM emissions were not estimated in that study which was concerned only with greenhouse gases.]

A rough estimate of motor vehicle emissions in the model domain (Kingston and most of St. Andrew) can be made by assuming the emissions are proportional to parish motor vehicle registrations. Kingston and St Andrew account for approximately 60% of motor vehicle registrations in 2005 so the SO_2, NOx, CO and NMVOC emissions in the model domain would be approximately 2,520, 10,260, 16,920, and 24,660 tonnes respectively.

The NOx emissions from the motor vehicle sources are about two thirds of the point source emissions while CO emissions are similar to the point source emissions in the model domain. It should be noted aircraft landings and takeoffs from Norman Manley International Airport (NMIA) will also contribute NOx, CO and NMVOC emissions. Estimates aircraft of these emissions for the entire island were respectively 980, 640 and 200 tonnes and hence are small relative to those from motor vehicles and point sources. It must be stressed that mobile sources are not included in the model runs and instead the background air quality levels for NO_2 and PM are assumed to include the contribution from all sources other than those listed in Table 4-19.

It is clear that the NOx and CO emissions from the refinery account for a very small percentage of the total emissions in the airshed and hence Petrojam's emissions will have a negligible impact on ambient air quality in the airshed. In contrast, Petrojam's SO_2, PM and VOC emissions although relatively small have the potential to affect ambient levels of these pollutants at least in the vicinity of the refinery.

Measurements of ambient levels of PM, SO_2 and NMVOC are therefore important in assessment of the existing ambient air quality in the vicinity of the refinery.

4.1.7 Existing Air Quality

The existing air quality was characterised by conducting ambient monitoring to measure levels of SO_2, NO_2, TSP and VOCs in the vicinity of the Petrojam refinery and also by reviewing recent (within the past five years) air quality data from monitoring conducted in the Kingston airshed.

In connection with their air quality licence applications, Petrojam and JPS – because of the proximity of the JPS Hunts Bay station and the Petrojam refinery, proposed to conduct joint ambient air quality monitoring for SO_2, NOx and PM_{10}. It was anticipated that the equipment ordered for that program would have been available for the EIA but unforeseen delays prevented the establishment of the three monitoring stations in time for data from those stations to be included in the EIA.

Instead, TSP was measured at two locations using a high volume (Hi-Vol) sampler and a Mini-Vol sampler. Since the Mini-Vol sampler is not among the approved equipment specified in the NRCA Air Quality Guideline Document, the Mini-Vol was collocated with a Hi-Vol in order to compare the measurements.

Similarly, because SO_2 and NO_2 instruments were not available, passive sampling methods were used at six stations as detailed below. One of the six stations was at Kelly Pen near Old Harbour where continuous SO_2 and NOx analyzers are available so that the measurements from the passive samplers could be compared with those from the continuous analyzers. The comparisons will not allow any indication of hourly levels (since the exposure period for the passive samplers is ~10 days) but will provide some measure of ambient air quality over a 10 day and longer periods.

4.1.7.1 Monitoring Methods and Results

SO_2 and NO_2

The principle of operation of the passive monitors is based on allowing the pollutant of interest to diffuse into a tube or through a membrane and then absorbing the pollutant in a chemical reagent with which it readily reacts. The absorbing reagent is removed at the end of the exposure period and analysed. In the case of NO_2 the absorbing reagent is triethanolamine and for SO_2 the absorbing reagent is KOH. Passive monitoring devices employing these sorbents were provided by Dr. Pinnock at the Chemistry Department UWI and their development and use has been described (Pinnock et. al., 2007).

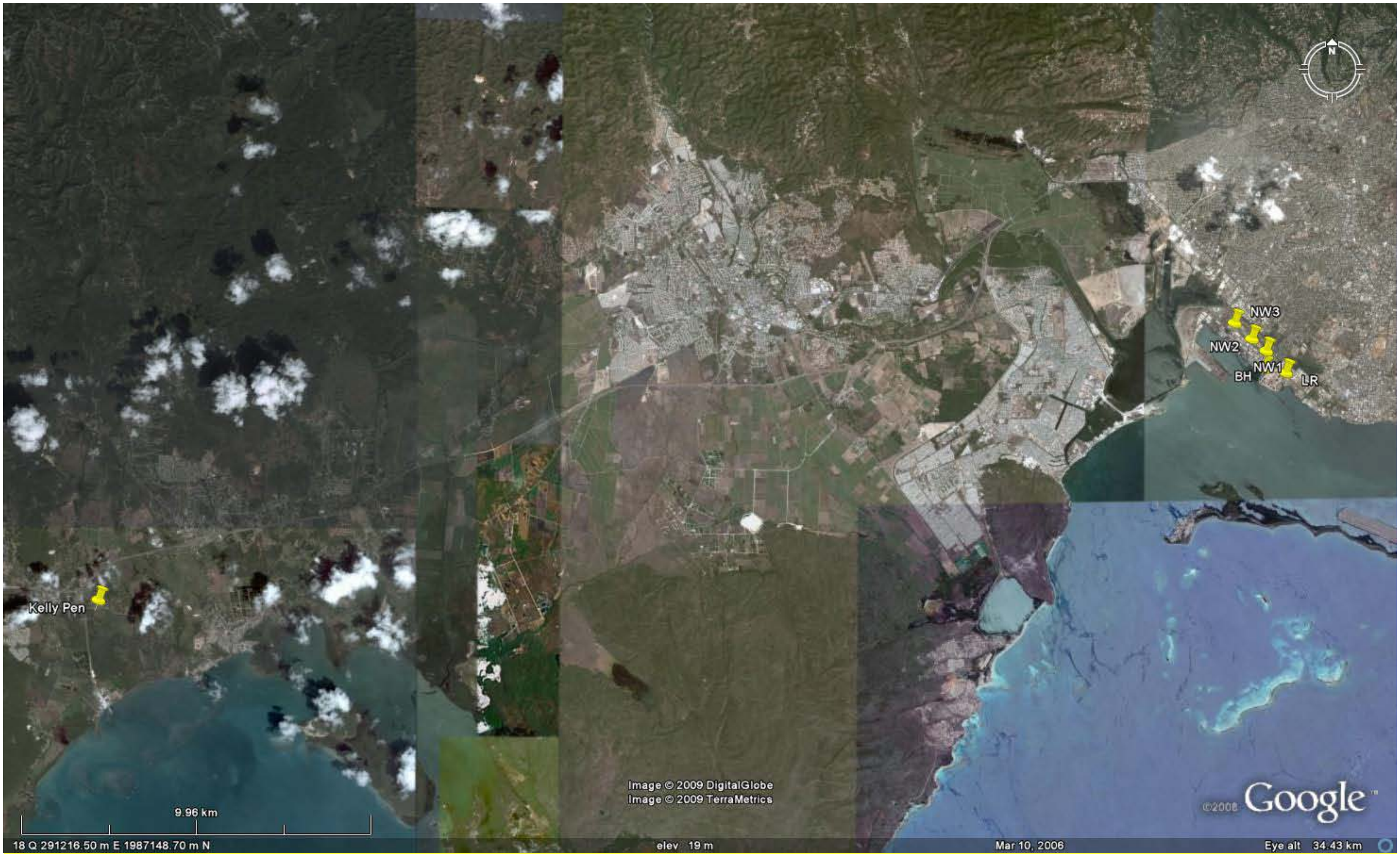
Pairs of the passive SO_2 and NO_2 passive monitors were deployed at five sites in the vicinity of the Petrojam refinery (see Figure 4-21) for periods of ~10 days. At a sixth site at Kelly Pen near Old Harbour (see Figure 4-22) continuous SO_2 and NO_2 analysers were also located so that comparisons could be made between the passive monitors and US EPA designated instruments that are adopted in the Jamaican Air Quality Regulations. The continuous analysers are an EnviroTechnology Model 100E Fluorescence SO_2 analyser and the Model 200E Chemiluminescence NOx analyser

Results from the passive monitoring of SO_2 and NO_2 and the data from the continuous analysers derived from the hourly averages at Kelly Pen are summarised in Table 4-22. The ratios of the measurements from the passive samplers to those from the continuous analysers at Kelly Pen were 0.74 for SO_2 and 0.87 for NO_2. This means that the passive samples gave on average

Figure 4-21 Locations of Ambient Monitoring Stations (Passive SO_2 and NO_2 and TSP) Near Petrojam

See Table 4-22 for key to monitoring stations

Figure 4-22 Location of the Kelly Pen (Near Old Harbour) Ambient Monitoring Site



See Table 4-22 for key to monitoring stations

Table 4-22 Summary of SO_2 and NO_2 Measurements Near Petrojam and at Kelly Pen

Location#	30 Nov -10 Dec 2008	10 Dec -23 Dec 2008	23 Dec 2008 -2 Jan 2009	2 Jan - 12 Jan 2009	12 Jan - 22 Jan 2009
	SO_2 ($\mu g\ m^{-3}$)				
BH	31.8	8.3	12.5	16.1	18.1
LR	17.7	12.7	16.2	22.7	23.1
NW1	21.2	11.5	16.7	39.7	29.1
NW2	12.8	17.4	13.4	34.7	24.6
NW3	15.4	18.8	18	29	14.7
KP	NA	4.4	4.1	3.6	6.6
KP (JEP)		6.3	5.8	5.8	7.0
	NO_2 ($\mu g\ m^{-3}$)				
BH	NA	NA	NA	16.7	16.5
LR	NA	NA	NA	15.9	17.8
NW1	NA	NA	NA	16	20.8
NW2	NA	NA	NA	19.8	19.3
NW3	NA	NA	NA	21.3	22.3
KP	NA	NA	NA	6.2	7.1
KP (KEP)		6.7	7.3	7.3	7.9

See Figures 4-21 and 4-22

BH Boat House
LR Loading rack
NW1 Newport West site 1
NW2 Newport West site 2
NW3 Newport West site 3

readings that were 26 % low for SO_2 and 13 % low for NO_2.

When it is required to estimate concentrations at (longer) averaging times different from when measurements are made, the following relationship (Equation 4-1) is used.

$$C_s = C_k \left(\frac{t_k}{t_s}\right)^p \quad \text{......... 4-1}$$

Where C s = concentration for (the longer) averaging periods

C_k= concentration for averaging period k
t_k= averaging period k
ts = averaging period s
p = an exponent in the range 0.17 to 0.75. The recommended value is 0.17.

Based on this relationship the ratio for the concentrations averaged over 1hr, 24 hr, 10 days (the duration of passive sampler exposure) and 1 year would be 1: 0.58: 0.39: 0.21. Since the NRCA standard for the annual mean SO_2 concentration is 60 $\mu g\ m^{-3}$ it is clear that the SO_2

concentrations at the monitoring sites near Petrojam will be well below the annual mean. It is also reasonable to expect that the measurements would also be well below the 1 hr and 24 h standards for SO_2. Similar arguments lead to the conclusion that the NO_2 measurements would also be well below the corresponding 1 hr Guideline and the standard for the annual mean.

TSP

TSP was determined by two factory calibrated Airmetrics Mini Vol samplers (MVS) one of which was co-located with a GCA Precision Scientific High Volume Sampler (HVS) at the Petrojam Boat House (BH). The HVS was also calibrated during the study. The Mini Vol samplers were located on utility poles approximately 4m above ground at the Garmex (GMX) and BH sites while the HVS was placed at ground level. Sampling was carried out every third day in accordance with the USEPA HVS sampling schedule calendar. TSP data are presented in Table 4-23 and are illustrated in Figure 4-23.

TSP levels from the Hi-Vol sampler at the Petrojam Boat House during the sampling period were in the range 4 to 91 µg m^{-3} with an average of 47 ± 23 µg m^{-3}. All values were well below the NRCA ambient air quality 24 hr standard for TSP (160 µg m^{-3}).

TSP levels at the loading rack site determined by the Airmetrics Mini Vol sampler were in the range 12 to 143 µg m^{-3}. The average for the period was 68 ± 47µg m^{-3}. All measurements were below the standard. As in the case of the Petrojam site, the lower levels were all determined towards the earlier period of the monitoring while all the relatively elevated levels were determined for the last three samples taken between December 5 and 11, 2008.

Comparison Between the MVS and the HVS at the Petrojam Boat House Site

TSP levels at the Petrojam Boat House determined by the Airmetrics Mini Vol sampler were in the range 21 to 223 µg m^{-3} (Table 4-23). The comparison between the two samplers was poor but the MVS on average showed higher measurements by a factor of 2.6. On this basis, although subject to considerable uncertainty, the Loading Rack MVS measurements (which were all below the NRCA standard) are likely to be even lower than that reported by the Hi-Vol sampler.

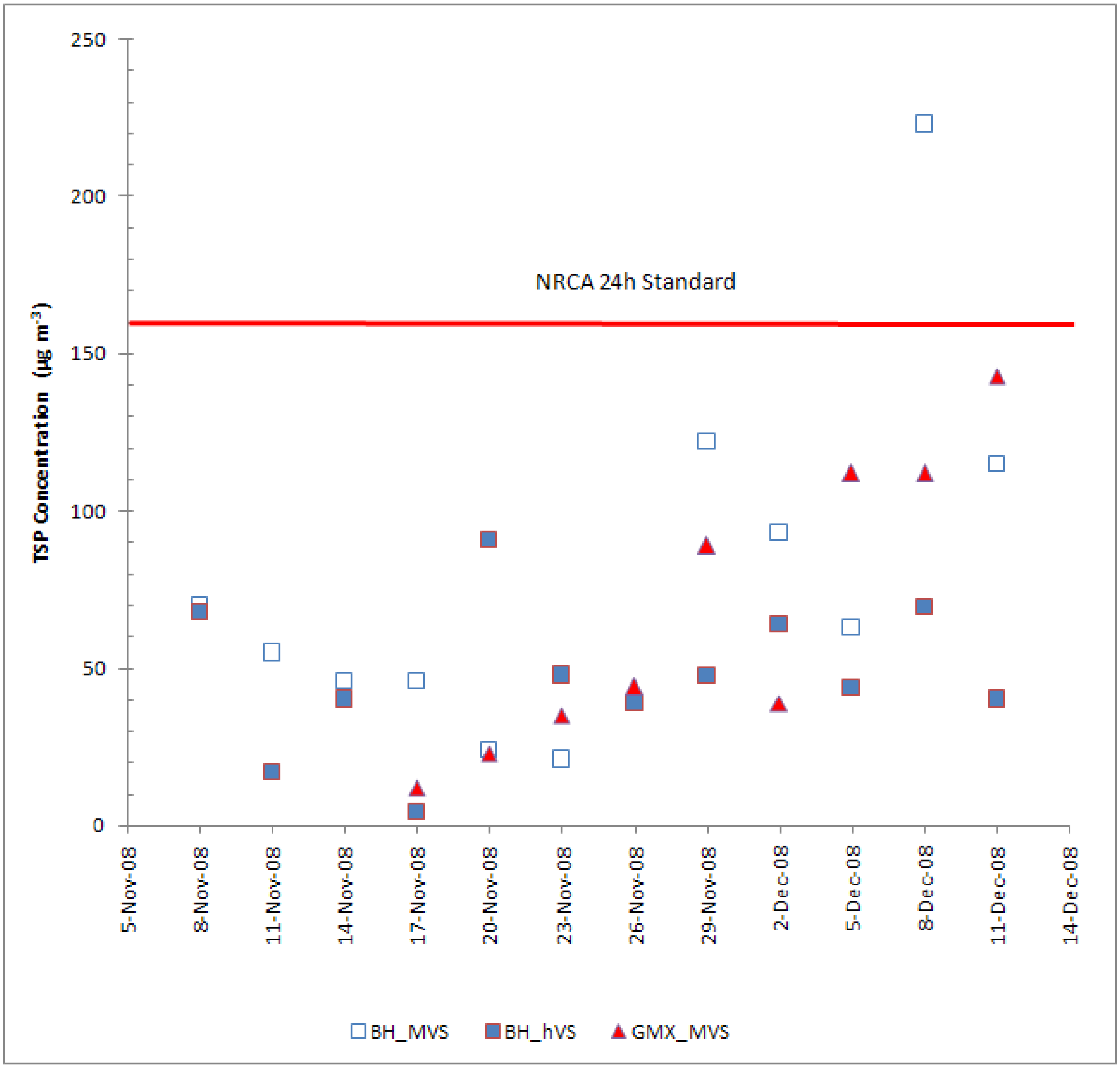
Table 4-23 Summary of Ambient TSP measurements at Monitoring Sites Near Petrojam November 8 To December 11, 2008

	Boat House (BH)			Garmex
Date	TSP MVS	TSP Hi-Vol	MVS/Hi-Vol ratio	TSP Mini-Vol
11/8/2008	70	67.9	1.03	
11/11/2008	55	16.8	3.27	
11/14/2008	46	40.3	1.14	
11/17/2008	46	4.3	10.81	12
11/20/2008	24	90.8	0.26	23
11/23/2008	21	47.9	0.44	35
11/26/2008		39.0		44
11/29/2008	122	47.5	2.57	89
12/2/2008	93	63.9	1.46	39
12/5/2008	63	43.6	1.44	112
12/8/2008	223	69.5	3.21	112
12/11/2008	115	40.3	2.86	143
AVG	80	34	2.59	68
SD	58	17	2.93	47
Max	223	65	10.81	143
Min	21	3	0.26	12

MVS Mini-Vol sampler

Hi-Vol High volume sampler

Figure 4-23 TSP Measurements at Monitoring Sites Near Petrojam November 8 to December 11, 2008



4.1.7.2 VOCs

Volatile organic compounds (VOCs) can be released to the atmosphere during the refining of crude oil into useful products. The main sources of these releases are from the storage of raw materials and products (storage tanks) as well as from leaks from the numerous valves and flanges in the refinery. Some of the unwanted gaseous hydrocarbons that are generated during the refining processes are burnt (flared).

Ambient levels of VOCs were measured using passive devices (3M Organic Vapour Monitor (OVM) 3500) that were exposed for 24 ± 0.2 h at five locations (Figure 4-24). Four of the locations are downwind from the prevailing winds at the refinery site and one site is upwind though close to the loading rack. Badges were exposed in duplicate at each site for five sampling periods between September and October 2008.

The individual VOCs measured include aromatic hydrocarbons (benzene, toluene, xylenes, 1, 3-diethylbenzene naphthalene), saturated hydrocarbons (n-pentane, 2,2-dimethylbutane, 2-methylhexane, 2,2,4-trimethylpentane, heptane, 2-methylheptane, octane, decane), two compounds released from vegetation and some consumer products (α-pinene, d-limonene) and two chlorinated solvents (trichloroethylene, tetrachloroethylene). Some of these compounds are included in the Priority Air Pollutant (PAP) list specified in the Air Quality Regulations and for which there are ambient air guideline concentrations. Table 4-24 lists the VOC analytes together with ambient air guideline concentrations from NRCA and selected jurisdictions.

The daily average concentrations of VOCs measured at the sites near Petrojam are summarised in Table 4-25. Benzene is the only compound whose measured concentrations are above the NRCA Guideline limit (see Table 4-24). The measured concentrations for the remaining compounds were lower (by factors ranging from 7 to 3300) than the corresponding limits[5].

The concentrations of tetrachloroethylene, trichloroethylene, 2,2-dimethylbutane, a-pinene, decane and d-Limonene showed no variation across the five monitoring sites hence indicating no nearby sources for these compounds.

The site LR had the highest concentrations of the other compounds (n-pentane, 2-methylhexane, benzene, heptane, 2-methylheptane, toluene, octane (m+p)-xylene, o-xylene, 1,3-diethylbenzene and naphthalene) and these concentrations were lower at the other sites. This indicates the presence of nearby sources. The LR site is located within 50 m of the loading rack where gasoline and diesel fuel are loaded on to tankers. These compounds are also expected to be emitted from traffic sources (evaporative and exhaust emissions) and because of this it is not feasible to distinguish between the exhaust and evaporative emissions from traffic and those from the refinery operations.

[5] For compounds with no limits for a 24 h averaging period, the measured 24 h average values were extrapolated to an annual average which was then compared to the annual limit.

Figure 4-24 Locations of Ambient VOC Monitoring Sites

See Table 4-22 for key to monitoring stations

Table 4-24 Standards and Guideline Concentrations for VOCs

Chemical	CAS No.	Standard or Guideline Concentrations in µg m^{-3}				Jurisdiction (Basis)
		10 min	1 h	24 h	Annual	
Benzene	71-43-2		 170 1300#	 30	1 4.5 0.13 60	NRCA Texas ESL (H) US EPA ARB (# 6 hr avg)
p-Xylene	106-42-3		5750 550	2300	 55	NRCA Texas ESL (H)
Tetrachloroethylene	127-18-4		900 2000	360	 26	NRCA, Ontario (H) Texas ESL (H)
Trichloroethylene	79-01-6		57.5 540	23 12	 2.3 54	NRCA Ontario (H) Texas ESL (H)
Xylenes	1330-20-7	 3000	5750 3700	2300 730	 370 180	NRCA Ontario (O) Ontario (H) Texas ESL (H) Health Canada
1,3-Diethylbenzene	141-93-5		2500		250	Texas ESL (H)
2,2,4-Ttrimethylpentane	540-84-1					
2,2-Dimethylbutane	75-83-2		3500		350	Texas ESL (H)
2-Methylheptane	107-83-5		3500		350	Texas ESL (H)
2-Methylhexane	591-76-4		3070		307	Texas ESL (H)
α -Pinene	80-56-8		60		6	Texas ESL (O)
Decane	128-15-5		60,000 10,000		 1,000	Ontario (H& O) Texas ESL (H)
d-Limonene	5989-27-5		1100		110	Texas ESL (H)
Heptane	142-82-5		 3,500	11,000	 350	Ontario (H) Texas ESL (H)
Naphthalene	91-20-3	50	 440	22.5	 44	Ontario (H) Texas ESL (H)
n-pentane	109-66-0		3500		350	Texas ESL (H)
Octane	111-65-9	61,800	 3500		 350	Ontario (O) Texas ESL (H)
Toluene	108-88-3		 640	2,000	 1200 3800	Ontario (O) Texas ESL (H) Health Canada

(O) Odour used as the basis for the ESL; (H) Health end point used as the basis for the ESL

Table 4-25 Summary of Average VOC Concentrations: (µg m^{-3}) Ambient Monitoring Sites

Compound	BH	NW1	NW2	NW3	LR
n-Pentane	14	47	11	6.5	72
2,2-Dimethylbutane	2.2	2.2	2.2	2.2	2.2
2-Methylhexane	3.9	9.5	2.5	2.6	22
Benzene	85	67	41	25	97
2,2,4-Trimethylpentane	4.3	4.9	3.9	4.2	5.2
Heptane	5.1	7.8	2.8	2.5	21
Trichloroethylene	2.5	2.2	2.9	2.2	2.2
2-Methylheptane	4.2	6.0	2.6	2.6	14
Toluene	15	47	13	13	89
Octane	2.8	3.4	2.6	2.6	9.1
Tetrachloroethylene	2.4	2.5	2.4	2.5	2.4
(m+p)-Xylene	8.5	28	6.8	6.4	76
o-Xylene	3.2	10	2.6	2.6	26
α -Pinene	2.1	2.1	2.1	2.1	2.1
Decane	3.0	3.0	3.0	3.0	3.0
d-Limonene	2.5	2.5	2.5	2.5	2.5
1,3-Diethylbenzene	2.4	2.7	2.4	2.4	7.3
Naphthalene	2.9	2.9	2.7	2.8	4.2

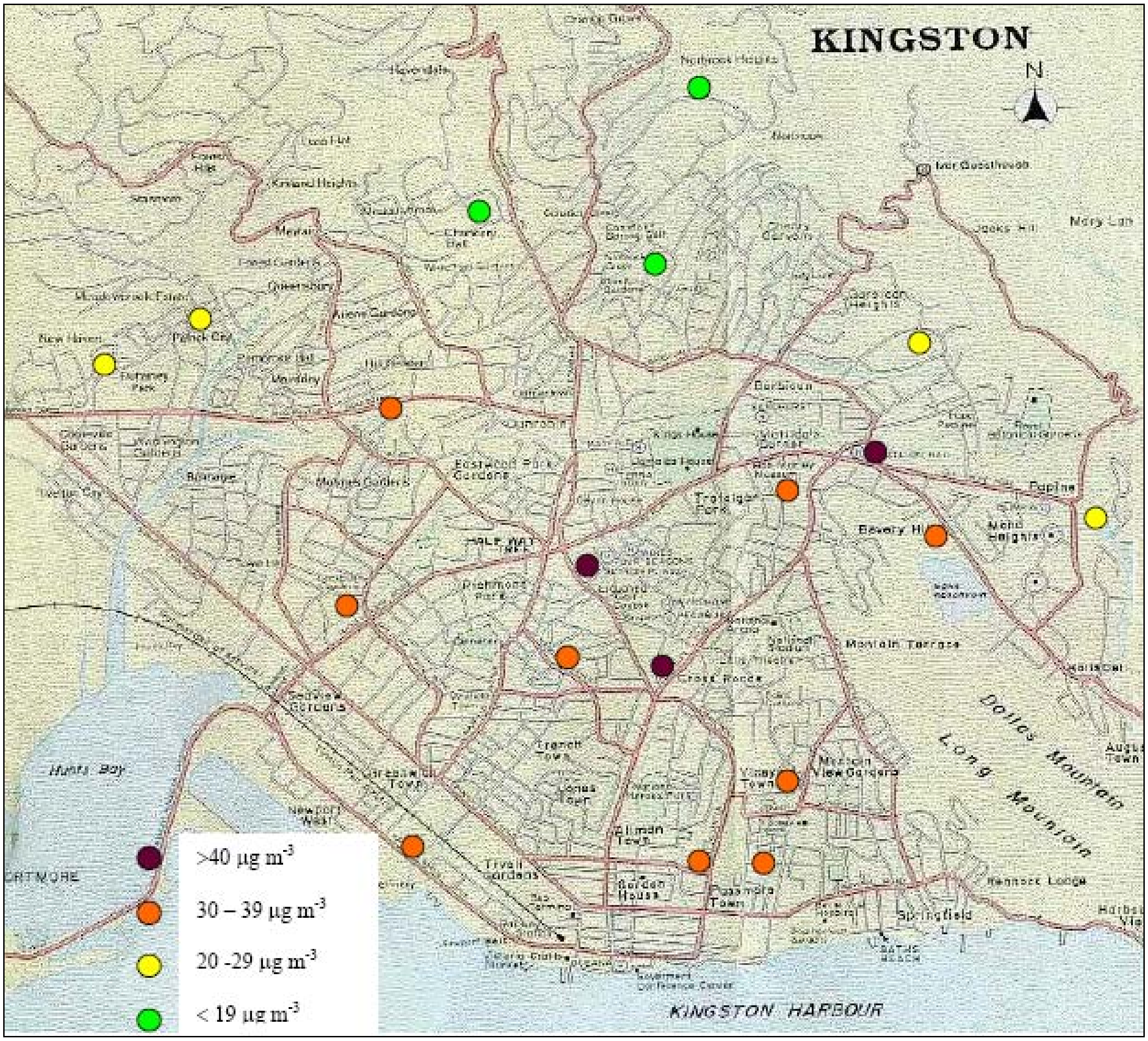
The second highest concentrations were at the Boat House (BH) site and the concentrations decreased as the distance downwind (towards the west) from the refinery (from NW1 to NW3) increased. It is therefore clear that the refinery is a source for the VOCs and apart from benzene; the measured levels are well below guideline concentrations. The potential impact of benzene will be addressed in the health risk assessment (see Section 6-45).

4.1.7.3 Historical Air Quality Data in the Kingston Airshed

Ambient air quality monitoring data for the Kingston area are limited. The National Environmental and Planning Agency (NEPA) has deployed continuous SO_2 and NO_2 monitors at one site (Cross Roads) and TSP and/or PM_{10} samplers at Cross Roads, Harbour View and 191 Old Hope Road. TSP measurements have been made for short periods at Half Way Tree.

Passive NO_2 monitors exposed at up to 19 locations in the Kinston & St Andrew airshed (see Figure 4-25) at various times during 2001, 2004 and 2006 recorded mean weekly averaged NO_2 concentrations ranging from 10 to 46 µg m^{-3}. The lowest weekly average NO_2 concentrations were at sites to the north of the study area (Chancery Hall, Norbrook Heights, and Constant Spring Golf Club). The highest measured NO_2 concentrations were at the Cross Roads, Half Way Tree and Matilda's Corner sites which were located near to high traffic road intersections. The weekly average NO_2 concentrations at a site located on Marcus Garvey Drive between the Refinery and the JPS Hunts Bay station were in the range 20 to 39 µg m^{-3}.

Figure 4-25 Distribution of Weekly Average NO_2 Concentrations in Kingston (November/December)*



* From Pinnock et al (2007)

The weekly average NO_2 concentrations for all exposure periods at all 16 sites when extrapolated to an annual average would be below the Jamaican National Ambient Air Quality Standard for the annual average NO_2 concentration of 100 µg m^{-3} hence it is unlikely that the annual standard for NO_2 could be exceeded at any of the monitoring sites.

Two-week average SO_2 concentrations made using the passive SO_2 monitors at up to six sites during April to July 2007 ranged from 7 to 42 µg m^{-3}. The highest values were measured at Camperdown High School which is located near to the power stations and a cement plant in the Rockfort area. None of the monitoring sites were located near to the refinery.

TSP and PM_{10} concentrations have been measured by NEPA at three locations (NEPA Office at Cross Roads [XRDS], NEPA Laboratory at 191 Old Hope Road [OHR] and at Harbour View [HV]). None of these sites is near to the refinery. The TSP and PM_{10} concentrations in 2006 and 2007 are respectively shown in Figures 4-26 and 4-27 and generally were below the 24 h JNAAQS.

NEPA used continuous SO_2 and NO_2 analysers to measure SO_2 and NO_2 levels at Cross Roads for limited periods between April 2006 and 2007 but only reported (Chinkoo, 2008) monthly average values. Although raw data (three minute averages) were provided (Chinkoo, 2008) it was not feasible to accurately determine time intervals in order to calculate hourly averages. The monthly average SO_2 concentrations ranged from 30 to 37 µg m^{-3} and suggest that the annual mean SO_2 concentration would be well below the JNAAQS for the annual average SO_2 concentration (60 µg m^{-3}). The report indicated that the highest hourly average NO_2 concentration was 77 µg m^{-3} – which is well below the NRCA Guideline concentration of 400 µg m^{-3} for a 1-hour average.

Figure 4-26 TSP Measurements at NEPA Kingston Airshed Monitoring Stations

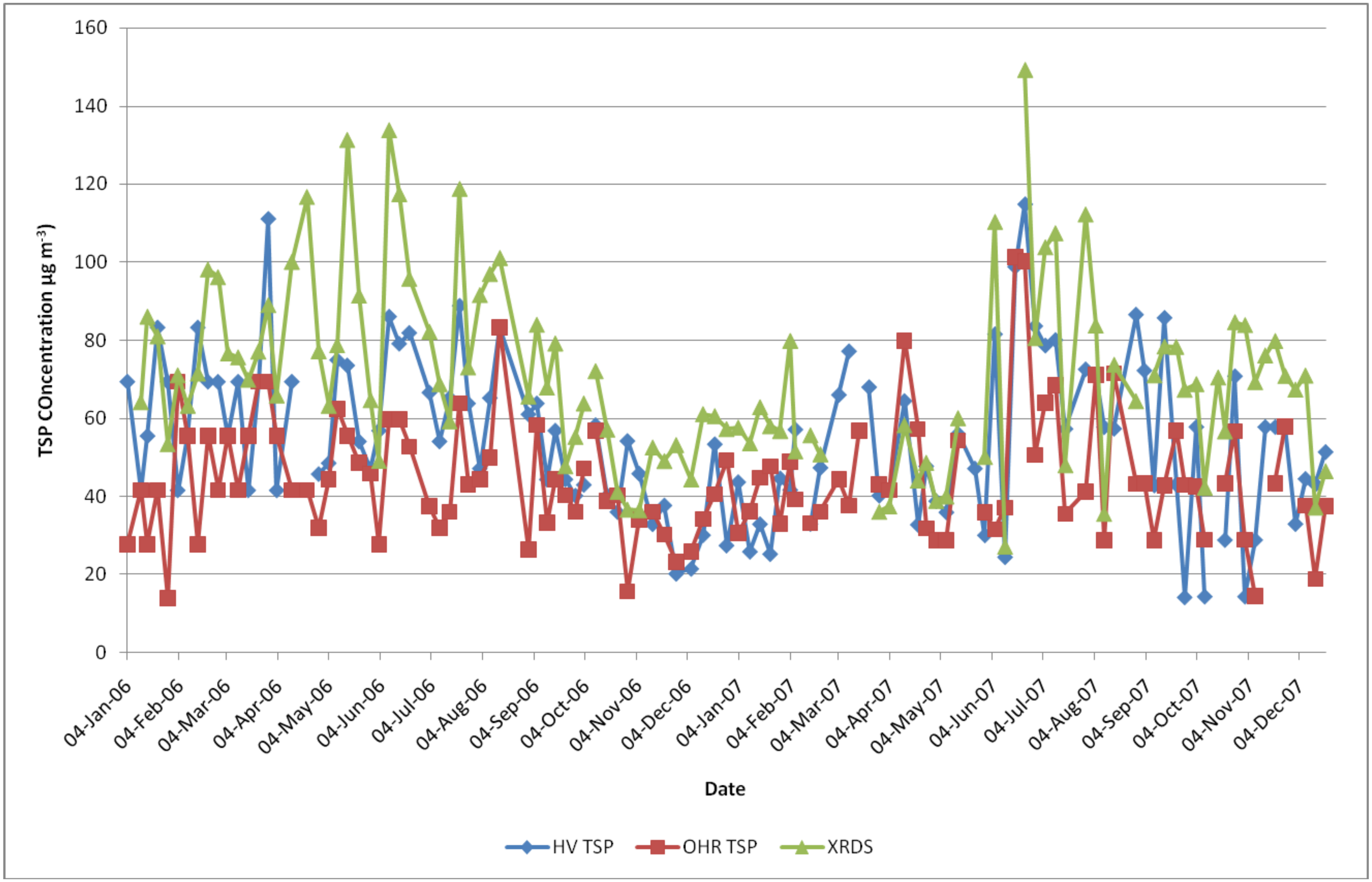
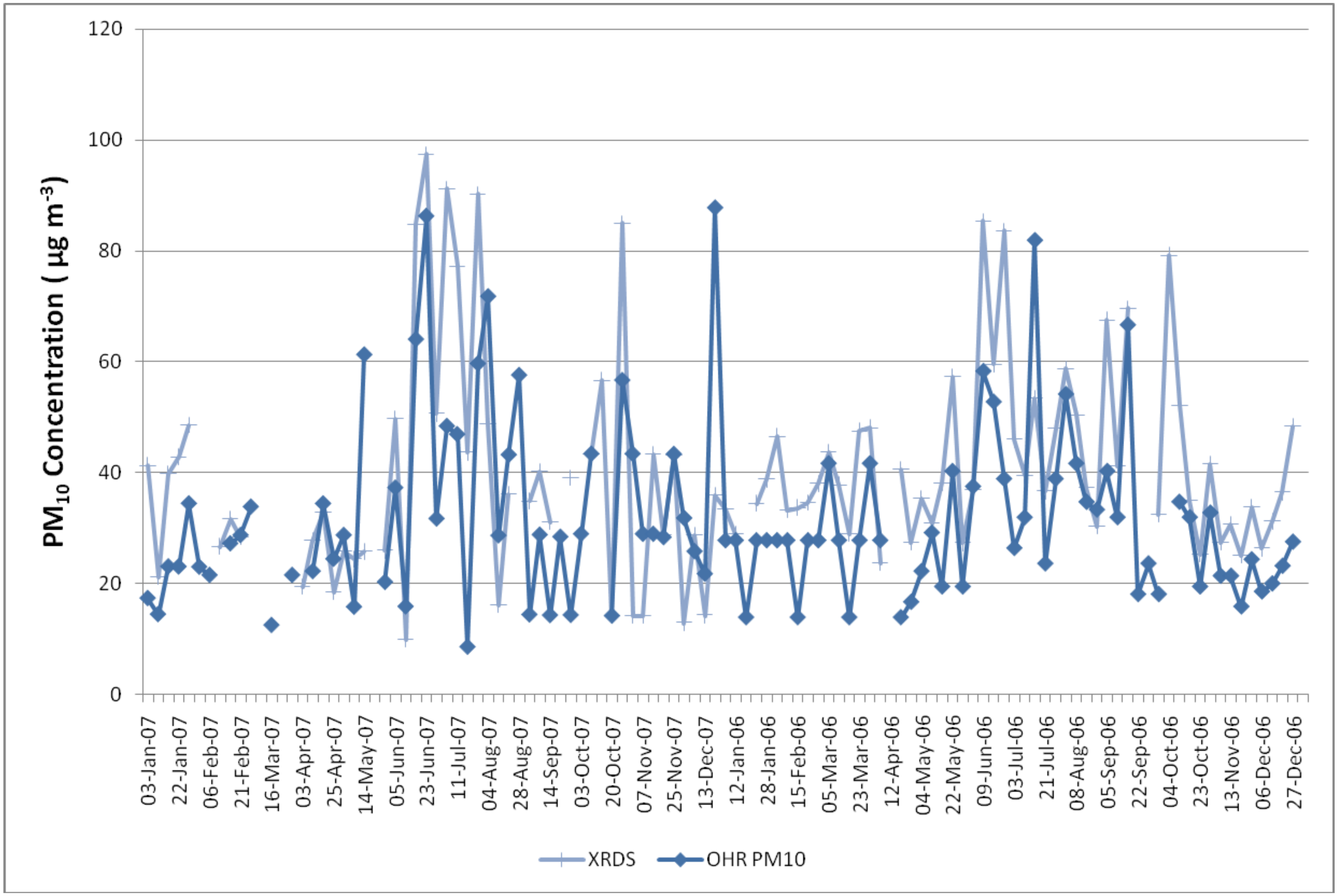


Figure 4-27 PM_{10} Measurements at NEPA Kingston Airshed Monitoring Stations



4.1.8 Occupational Health Surveys

4.1.8.1 Noise

Noise was measured using the Cirrus 1:3 CR800 Integrating averaging sound level meter which meets the requirements for IEC 61260 Class 1 sound level meters. The instrument is capable of making continuous measurements for up to 24 hrs. The Deaf Defier software provides an interface for downloading data to PC. The CR800 in 1:3 mode performs a sweep of the filter bands over the measurement duration providing the signature of the noise sources. In addition to amplitude of the individual frequency bands, the instrument directly outputs the continuous equivalent A-weighted sound level (LA) for the period of measurement.

Noise measurements are evaluated against permissible noise exposures taken from the US Department of Labour OSHA Standard for Occupational Noise Exposure summarised in Table 4-26. Also taken into consideration is the action level of 85db (time weighted 8-hr average), the level at and above which, employees shall be provided with hearing protection.

Eight sets of sound level measurement were made at the refinery in the following areas: process unit (near stack F1), smoking shed, laboratory (engine room), maintenance workshop, administration building (lobby), and the guard-house at the main gate. For each set of readings the meter was programmed to run for the entire duration of the shift (12hrs). The survey was carried out between September 4 and 23, 2008. As activities in the maintenance workshop and laboratory were expected to vary, these sites were investigated on two occasions. The measurements are summarised in Table 4-27.

Continuous equivalent A-weighted sound level (LA) measured at the main work stations ranged from a high of 93.4dbA at the Process Unit to a quiet 48.1dbA in the lobby of the Administration building. In addition to the Process Unit other work areas having noise levels near the Action Level included the Smoke Shed and The Maintenance Workshop. At the smoke shed LA was determined to be 79.5 dbA while in the maintenance workshop, LA was determined to be 82.8dbA on the first occasion (September 8, 2008) and 65.4dbA on September 15, 2008. The main source on the Process Unit as well as the Smoke Shed was Furnace F-1. Activities contributing to noise levels in the Maintenance Workshop were mainly associated with air blasting from pressure testing and metal works (hammering). In the laboratory, the engine room represents the main source of noise.

Petrojam uses signs and requires adherence to the use of personal protective equipment in high noise areas.

Table 4-26 Permissible Noise Exposures

Duration Per Day (hrs)	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

Source: OSHA 1910.95

Table 4-27 Occupational Noise Data – Petrojam: September 2008

Site	Date	LA	PEAK DB	Peak Frequency Range (Hz)	Noise Source(s)
Process Unit	9/4/08	93.4	91.3	200 - 400	Furnace - F1
Smoke Shed	9/10/08	79.5	81.8	40 - 315	Furnace - F1
Maintenance Workshop 1	9/8/08	82.8	83.9	630.00	Air Blast, Metal Works
Maintenance Workshop 2	9/15/08	65.4	73.0	630 - 1250	Air Blast, Metal Works
Laboratory 1	9/9/08	67.5	77.2	25 - 160	Engine
Laboratory 2	9/23/08	67.4	78.8	40 - 125	Engine
Admin Building Lobby	9/11/08	48.1	73.3	50.00	Conversation, TV At Low Level
Guard house Main Gate	9/12/08	70.2	74.5	50 - 100	Conversation
Action Level (8 hr)		85.0			
Standard (8-hr)		90.0			

4.1.8.2 VOCs

Occupational levels of VOCs were measured at the following locations which were deemed to be representative of the locations where all types of workers could be exposed to VOCs.

Location	**Abbreviation**
Administrative Office Building	ADMIN
Control Room	CR
Guard House	GH
Laboratory	LAB
Processing Unit (East)	PUE
Processing Unit (West)	PUW
Smoke Shed	SS

Figure 4-28 shows the locations of the occupational monitoring sites.

VOCs were measured using passive samplers (3M Organic Vapour Monitor (OVM) 3500) which were deployed in pairs at each location for the duration of a shift (12 hours). After exposure, the badges were analysed by extracting the sorbent in 2 mL of solvent which was analysed for 18 VOCs by gas chromatography/mass spectrometry (GC/MSD) with a detection limit of 0.05 µg/sample or ~0.002 mg/m^3. Field blanks were corrected with solvent, and reported as µg/sample. Quality assurance and quality control included using laboratory and field blanks, and multipoint calibration curves for each analyte (R^2 >= 0.99) and an internal standard (toluene-d8). VOCs analysed include those expected to be released from refinery products and raw materials and compounds released by vegetation and some consumer products (α-pinene and d-limonene). Tetrachloroethylene is used in the refinery and the laboratory and also can be indicative of human activity (dry cleaning).

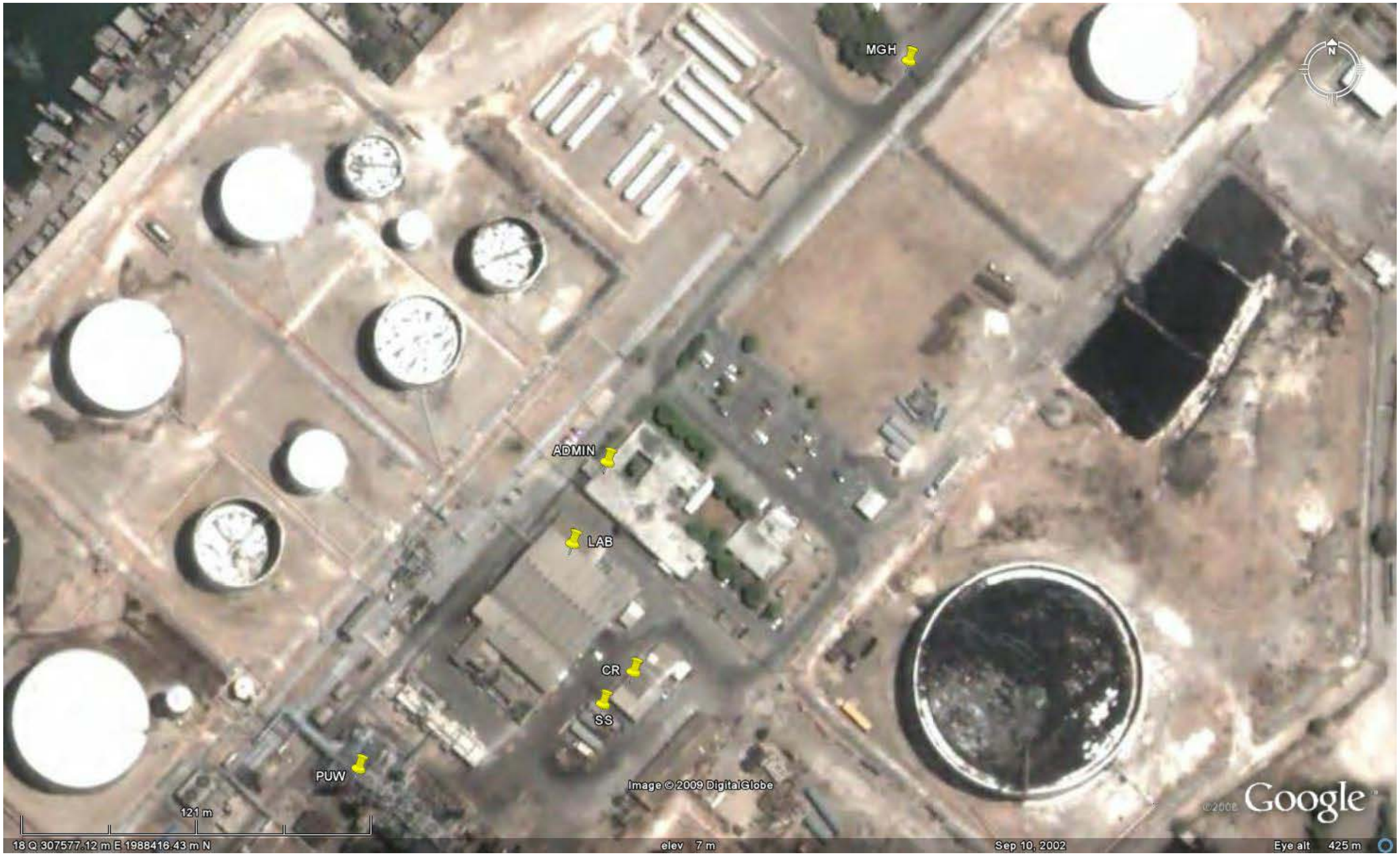
Table 4-28 shows the average concentrations at each location.

The concentrations are all below the NIOSH standards (8 h time weighted average concentration) or Threshold Limit Values (TLV).

The highest concentrations were in the laboratory (LAB) and the process areas (PUE, PUW). The high levels in these areas are due to the presence of reagent solvents (in the laboratory) and fugitive emissions (from valves and flanges in the process area). The concentrations were higher at the western location in the process area than at the eastern location. This is consistent with the prevailing winds from the southeast.

Fume hoods are used in the laboratory and personal protective equipment is required in high VOC exposure areas.

Figure 4-28 Locations of Occupational Monitoring Sites



CR Control Room; MGH Main Gate Guard House; LAB Laboratory; PUE Processing Unit (East); PUW Processing Unit (West); SS Smoke Shed

Table 4-28 TWA limits (mg m^{-3}) and Average VOC Concentrations (µg m^{-3}) at Occupational Exposure Monitoring Sites###

Compound	TWA Limit (mg m^{-3})	ADMIN	CR	GH	LAB	PUE	PUW	SS
n-Pentane	2950	114	72	74	297	437	762	125
2,2-Dimethylbutane	NA	2	2	2	67	3	3	2
2-Methylhexane	NA	19	17	9	78	92	218	15
Benzene	3.19 16 # 31.9##	90	86	286	148	102	275	66
2,2,4Trimethylpentane	300 (TLV)	10	7	6	856	10	15	6
Heptane	2000	36	36	14	375	288	638	32
Trichloroethylene	2	2	3	2	18	3	3	2
2-Methylheptane	300	16	22	4	70	105	228	11
Toluene	2	53	84	30	907	217	512	32
Octane	2350	13	34	6	93	161	356	12
Tetrachloroethylene	2	2	2	2	37	5	10	2
(m+p)-Xylene	435	29	98	15	520	135	335	19
o-Xylene	435	10	35	5	158	51	114	7
a-Pinene	NA	2	2	2	3	3	3	2
Decane	NA	3	40	3	70	38	83	5
d-Limonene	NA	7	16	3	6	4	4	3
1,3-Diethylbenzene		3	10	3	24	11	23	3
Naphthalene	50	5	5	4	10	6	7	3

Short term exposure level (STEL) (15 minute average)

Applicable to loading rack

Measurements were made between September 8 and 22, 2008.

4.1.9 Emergency Response Plans

Petrojam has developed and documented a comprehensive Health, Safety, and Environmental Management (HSEM) program that includes emergency response plans. The program is based on process safety management and is based on voluntary compliance with the United States Occupational Health and Safety Administration (OSHA) regulations 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals. The OSHA regulations are more comprehensive than the applicable Jamaican legislation that govern Petrojam's operations. The applicable legislations are the Factories Act 1968, the NRCA Act 1990, and the Petroleum Quality Control Act 1991. At this present time the OSHA regulations are more stringent than the draft Jamaican requirements. A Guidance Document (Petrojam, 2009) defines Petrojam's overall emergency response policy, organization and processes in implementing and continually improving the various emergency procedures. The key objectives of the emergency response plans are summarised in the text box on the following page. The plans undergo continuous revision and improvement (including ongoing training and drills) to reflect best practices in the refining industry (Fire Emergency, Oil Spill Response, ISPS) as well as for civil society (e.g., Evacuation, Civil Unrest, Hurricane Preparedness & Response, Earthquake).

The emergency response plans fall under the following headings:

Fire Emergency Plan
Oil Spill Response plan
International Ship and Port Security Code Plan (ISPS) plan
Evacuation Plan
Civil Unrest
Hurricane Preparedness and Response
Earthquake Response Plan

The key elements of these plans are summarised in Table 42 9. An integral part of the emergency response plans are protocols for notification of relevant national emergency agencies (Police, Fire Brigade, Ambulance, NEPA, Port Authority, Coast Guard) and communication with nearby residents and businesses. Petrojam has instituted a Community Outreach Committee and an outreach program that includes regular meetings with Community Development Committees. However, it was noted at the public meeting that there was need for improvement in the communication/warnings to nearby residents during emergencies and participation in emergency response planning.

Principal Objectives of Petrojam's Emergency Planning and Response Program

- To provide guidance for, training, personal protective equipment and general requirements and responsibilities relative to the mitigation of those emergencies that may arise at this site. Emergencies include fire, hydrocarbon or chemical spill and release, hurricane, earthquake, bomb threat, man-down and others that may be defined by the plant management.

- To comply with emergency response requirements (paragraph "*n*" which incorporates requirements from other existing regulations) of the USA OSHA Regulation 29 CFR 1910.119 -*Process Safety Management of Highly Hazardous Chemicals*.

a) To establish and implement an emergency action plan for the entire plant in accordance with USA OSHA Regulation 29 CFR 1910.38(a). (This standard requires alarm systems complying with 29 CFR 1910.165)

b) To establish and implement procedures for handling small releases

c) To comply with the provisions of the USA OSHA Regulation 29 CFR 1910.120(a), (p), and (q) -*Hazardous Waste Operations and Emergency Response* (HAZWOPER).

d) To comply with USA regulations 40 CFR Parts 264 and 265 of the *Resource Conservation and Recovery Act*.

e) To comply with portions of the USA regulation 40 CFR Part 68 – *Risk Management Plan* (RMP) with respect to on-site and off-site environmental impacts.

- To provide guidance for informing the mutual aid resources (such as the Kingston based fire departments ambulance services, and police force) and the Local Area Planning Authorities as they are created, of any incident that has the potential for offsite impacts.

To provide guidance on notifying the public of such an incident and on initiating any offsite measures in consultation with the mutual aid resources or planning authorities.

Table 4-29 Descriptions of Petrojam's Emergency Response Plans

Plan	Comments/Description
Fire Emergency Plan	Defines Petrojam's role in responding to fires and defines the roles of relevant Government agencies (NEPA, ODPEM, Port Authority, NWA, JDF Coast Guard, JFB, NWC) and NGO'S.
Oil Spill Response plan	The plan addresses the full range of spills in Jamaican coastal waters, and particularly in the Kingston, Portland Bight and Montego Bay harbours. And is complementary and subordinate to the National Oil Pollution Contingency Plan. Includes cooperation and mutual aid with other petroleum marketing companies (ESSO, SHELL, TEXACO, and PETCOM) under the "Oil Pollution Control Committee" (OPCC). Upon request, PETROJAM will make its resources available to the JDFCG or OPCC
International Ship and Port Security Code Plan (ISPS) plan	The ISPS is a code adopted by the International Maritime Organisation (IMO). It is designed to protect ports and international shipping against terrorism. The Port Authority of Jamaica has adopted the ISPS and all companies which use port facilities must be in compliance with the code.
Evacuation Plan	This plan complements and refers to all other plans that require evacuation. Includes specific procedures for the loading rack.
Civil Unrest	Includes procedures that will enable Petrojam to effectively prepare for and/or respond as needed to civil unrest that may impact on refinery operations.
Hurricane Preparedness and Response	The plan establishes the policy and procedures for protecting Petrojam personnel and facilities in preparation for hurricane-force weather.
Earthquake Response Plan	Provides a framework for coping responsively to an earthquake and assigns responsibilities to meet the emergencies that may arise. This plan supports the National Earthquake Response Plan (Jamaica) and other plans used to respond to an earthquake at Petrojam Limited. The key objective is to save lives and minimise damage to equipment and property.

The status of the plans can in part be assessed through examination of annual reports on incidents that cause the plans to be exercised as well as ongoing drills and the review and upgrading of the plans.

Over the past three years there were a total of 88 incidents (see Table 4-30) at least 11 of which required detailed investigations. The program also included site inspections. Some of the safety issues identified by the inspections and corrected as a result include leaks from valves and flanges, pinhole leaks in piping, unsafe electrical wiring and minor structural disrepair.

Table 4-30 Summary of (Non - Injury) Incidents at Petrojam, April 2005 to March 2008#

Year	Fires	Land Spill	Marine Spill	Other	Total	Detailed Investigation	Inspections
2005 - 2006	7	6	1	16	30	5	24
2006– 2007	8	4	15	0	27	6	34
2007 - 2008	6	11	0	14	31		36

From Petrojam Refinery Safety Reports, 2005-2006, 2006-2007 and 2007-2008

4.1.10 Waste Management

4.1.10.1 Liquid Wastes

There are two discharges of liquid effluent from the Petrojam refinery. Various fugitive and refinery wastewater process streams and blowdown from a cooling tower are collected in the API separator to remove oil before the wastewater is discharged. The typical discharge volume is ~136,260 l/day. The second discharge is from the storm water drain which also receives the rejected water from the reverse osmosis system and boiler blowdown water. Petrojam routinely measures water quality in the effluent from the (API) separator and the storm drain.

The effluent from the separator is sampled 3 to 5 days per week and samples are analysed for temperature (Temp), total dissolved solids (TDS), total suspended solids (TSS), oil, pH, conductivity (Cond.), sulphides, dissolved oxygen (DO) and chemical oxygen demand (COD).

Statistics (maximum value (Max), average, standard deviation and number of samples (Count)) and the number of times the standard was exceeded (No >Std) for API separator effluent and the storm drain for 2007 and up to April 2008 were summarised in Table 4-14. Also included in Table 4-14 are the proposed NRCA trade effluent water quality guideline values.

In general, the data indicate that effluent from the API separator exceeded the NRCA Trade

Effluent Standards for temperature, dissolved solids, oil, pH, COD and sulphides. Suspended solids were generally low and within the proposed NRCA trade effluent standard.

4.1.10.2 Solid Waste

Processing Solid Waste

Solid waste associated with operation of the plant may be classified as the following types: industrial sludge, spent catalyst, desiccant, silica balls, metal scrap, office and toilet waste and waste from the canteen. Types of solid waste and estimated quantities generated are summarized in Table 4-31. Spent hydrofiner catalysts and chloride adsorbents are placed in drums, held on site in a designated area and accumulated into batches until the size is suitable for shipment overseas to recycling companies. The UOP R86 platforming catalyst is sent back to the vendor for recovery of metallic platinum. Spent inert silica balls are stored on site in drums and incorporated in concrete mix used mainly in the bund walls of the tank farm.

Sludge is collected from Jamaica Energy Partners (JEP) and is also generated on site as a result of tank cleaning operations. All sludge is treated in the sludge reprocessing plant which involves centrifugal separation to produce solids, hydrocarbons and oily water. The remaining solids are stored in drums and held on site in a designated area. Hydrocarbon liquids recovered from the centrifuge are returned to crude and the resultant oily water is sent to the API separator.

Domestic Solid Waste

Office and canteen wastes are held on site in three skips and transported to the municipal solid waste management site twice weekly by a contracted garbage disposal service.

Table 4-31 Solid Waste Generated At Petrojam Refinery

WASTE TYPE	SOURCE(S)	CHARACERISTIC	HAZARD RATING*	Tonne/Yr (est)	DISPOSAL
Industrial Sludge	Tank Cleaning Operations	Hydrocarbon Sludge	NA	.3	Centrifugal separation of solids, water and hydrocarbons
	Jamaica Energy Partners (JEP)	Heavy Black Carbon or Diesel Sludge	NA	2	
Spent Catalyst	D12, D15	Catalyst Pellets	NA	#	Stored In drums and returned to suppliers
	D14	Odourless Green Extrudates (<2.5cm)	H2 F0 R0	#	
	D7, D8, D9.	R-86 Platforming Catalyst	H1 F0 E0	#	Platinum recovered
Adsorbent	D16	PCL-100 Adsorbent, Contains <3% Quartz, a Known Carcinogen	H1 E0 R1	#	Stored In drums and returned to suppliers
	D17	Alcoa CL 750	NA	-#	
Putrescible Solid Waste	Canteen	Meal scraps, Kitchen waste, Disposables	0	NA	Taken to Municipal Solid Waste Disposal Site
Municipal Waste	Administrative Offices, Laboratory, Control Room, Toilet/Changing Rooms/Toilets	Paper, Cardboard, Miscellaneous Packaging Material	0	NA	Taken To Municipal Solid Waste Disposal Site
Metal Scrap	Process Unit	Obsolete Machinery, Spent Components,	0	NA	Held on site
	Maintenance Workshop	Metal Working Scrap			

Catalysts and adsorbents have varying lifetimes and hence are not necessarily generated on an annual basis.
NA Estimates or hazard rating are not available

4.2 BIOLOGICAL ENVIRONMENT

The proposed modifications to the refinery facility relate to increasing the processing capability of the plant.

The primary objective of this study was to provide an overview of the biological status of terrestrial and marine areas in and around the refinery that are likely to be impacted by the proposed development activities. The assessment focuses on identifying any potential impacts to the ecology of the area occurring as a result of the proposed plant upgrade activities. Other objectives include identifying presence/absence/extent of ecologically or commercially important species of terrestrial and aquatic flora/fauna in the study area; determining potential interactions between natural features, species and habitats during the construction and subsequent operational phases of the upgrade; formulate possible mitigation measures once impacts are identified.

4.2.1 Methodology

The methodology entailed the following:

- Obtaining up-to-date satellite imagery or aerial photographs of site and study area;
- Ground-truthing of imagery to identify major ecological assets/resources (ecologically or commercially important floral/faunal species in both terrestrial and aquatic communities); and
- An assessment and classification of the relevant terrestrial and marine communities conducted on 10th & 11th August 2008 to determine the presence of ecologically or commercially important species of flora/fauna at or immediately adjacent to the site. Species of flora and fauna were identified on location.

The primary terrestrial faunal communities examined were: the macro-flora which were assessed using a simple walkthrough of the compound and visual presence / absence counts; and the avifauna which were documented during the walkthrough exercise and ranked according to the following scheme:

R = resident;
E = endemic;
I = introduced;
W = winter migrant; and
S = summer migrant, criteria.

Both the pelagic and benthic marine communities were assessed. Plankton tows were used to sample the pelagic marine community for later examination. Sampling of the marine benthos via photographic transects was impossible due to poor underwater visibility at the time of survey. Two, 300m long randomly placed transects were examined at 1m intervals in the locations shown (with core sampling of substrate at various points along each transect) to determine substrate composition. Mobile or attached corals and algae were identified to the species level where possible. Poor visibility also made it impossible to execute a proper fish survey.

4.2.1.1 Results - Terrestrial Environment

The Petrojam site has been industrially/commercially developed. Approximately 40-45% of the site is constituted by hard surface area from petroleum tanks and road surfacing. The remainder is bare, open, exposed ground, partly covered by fine marl sediments, common grasses (*Sporobolus indicus* – rat tail grass), ornamental shrubs and almond trees scattered throughout the site especially on its margins. No rare or endemic plant (or other faunal) species were noted and biodiversity was particularly low due to previous and continued clearing of vegetation onsite as well as the manner of use of this site which precludes heavy vegetative cover anywhere onsite. Plant species on the site are listed in Table 4-32.

Table 4-32 List of Plant Species Recorded Onsite

Family Name	Botanical Name	Common Name
Combretaceae	*Laguncularia racemosa*	White mangrove
	Thespecia grandiflora	Seaside Mahoe
	Hibiscus tiliaceus	
	Sporobolus sp.	Tufted grass
	Arundinella conifis	Common tufted grass
Bignoniaceae	*Tecoma stans*	
Combretaceae	*Terminalia catappa*	Almond

4.2.1.1.1 Avifauna

During the site visit the few birds seen were engaged in foraging activities. These included common resident species such as the Egrets (*A. alba* & *E. thula*) and herons (*E. caerulea*). The marine environment immediately offshore the facility has potential to act as a feeding area for herons and other birds but the longstanding pollution of the harbour by industrial effluent, oil spills, sewage and storm water runoff has made the area unattractive as a primary habitat or feeding area for birds. The recent startup of the Soapberry wastewater treatment plant and the diversion of effluent from the poorly functioning Greenwich and Western Sewage Treatment plants to Soapberry should significantly improve water quality in Kingston Harbour.

4.2.1.1.2 Marine Environment

Phytoplankton was collected via 5 minute tows along a track perpendicular to shore at 25m and 400m from the shoreline. Results are shown in Table 4-33. The inshore sample was more diverse than the offshore sample however 17 of the total 29 species were common to both samples. Both samples were dominated by net-plankton belonging to large diatom species, confirming that the samples were collected from nutrient enriched waters. One potentially toxic species of phytoplankton namely *Dinophysis caudata*, known to cause Diarrhetic Shellfish Poisoning in other parts of the world, was present in the offshore sample.

Two dives were conducted on the 10^{th} of August, 2008 at the locations shown in Figure 4-29. The depth along Transect 1 ranged between 4.88m and 5.8m while on Transect 2 the depth range was 4.27m to 4.88m. No benthic or mobile resources were noted during either transect swim.

The substrate along Transect 1 consisted of a grey anoxic mud as shown in Figure 4-30. There were no organisms present large enough to see with the naked eye.

Table 4-33 Results of Phytoplankton Analyses

SAMPLE ID: 25m from shore	
SPECIES	**Cells/litre**
Amphora ventricosa	8,999
Amphora sp. A	8,999
Bacteriastrum delicatulum	8,999
Ceratium furca	8,999
Ceratium trichoceros	26,997
Chaetoceros atlanticus	44,996
Chaetoceros sp. C	161,984
Coscinodiscus centralis	629,937
Cylindrotheca closterium	17,998
Gyrosigma balticum	8,999
Hemialus hauckii	98,990
Leptocylindrus danicus	26,997
Melosira sp. A	8,999
Navicula cancellata	35,996
Navicula cincta	35,996
Navicula cruciculoides	8,999
Navicula sp. F	8,999
Nitzschia sp. F	71,993
Nitzschia sp. G	8,999
Oscillatoria sp. A	17,998
Oscillatoria sp. B	26,997
Oscillatoria sp. C	8,999
Pleurosigma sp. A	8,999
Pseudosolenia calcar-	8,999

SAMPLE ID: 150m from shore	
SPECIES	**Cells/litre**
Bacteriastrum delicatulum	40,500
Ceratium furca	13,500
Ceratium trichoceros	13,500
Chaetoceros atlanticus	135,000
Chaetoceros sp. C	337,500
Coscinodiscus centralis	1,876,500
Cylindrotheca closterium	81,000
Dinophysis caudata	27,000
Hemialus hauckii	13,500
Leptocylindrus danicus	27,000
Melosira sp. A	13,500
Navicula cincta	13,500
Nitzschia sp. F	189,000
Pseudosolenia calcar-avis	13,500
Spirulina princeps	351,000
Striatella unipunctata	13,500
Thalassionema frauenfeldii	135,000
Thalassionema nitzschioides	3,699,000
n=18	

SAMPLE ID: 25m from shore	
SPECIES	**Cells/litre**
avis	
Rhizosolenia alata	8,999
Rhizoslenia setigera	8,999
Spirulina princeps	251,975
Thalassionema frauenfeldii	116,988
Thalassionema nitzschioides	2,699,730
n=29	

SAMPLE ID: 150m from shore	
SPECIES	**Cells/litre**

Where n = Population size

Figure 4-29 Transects for Dives

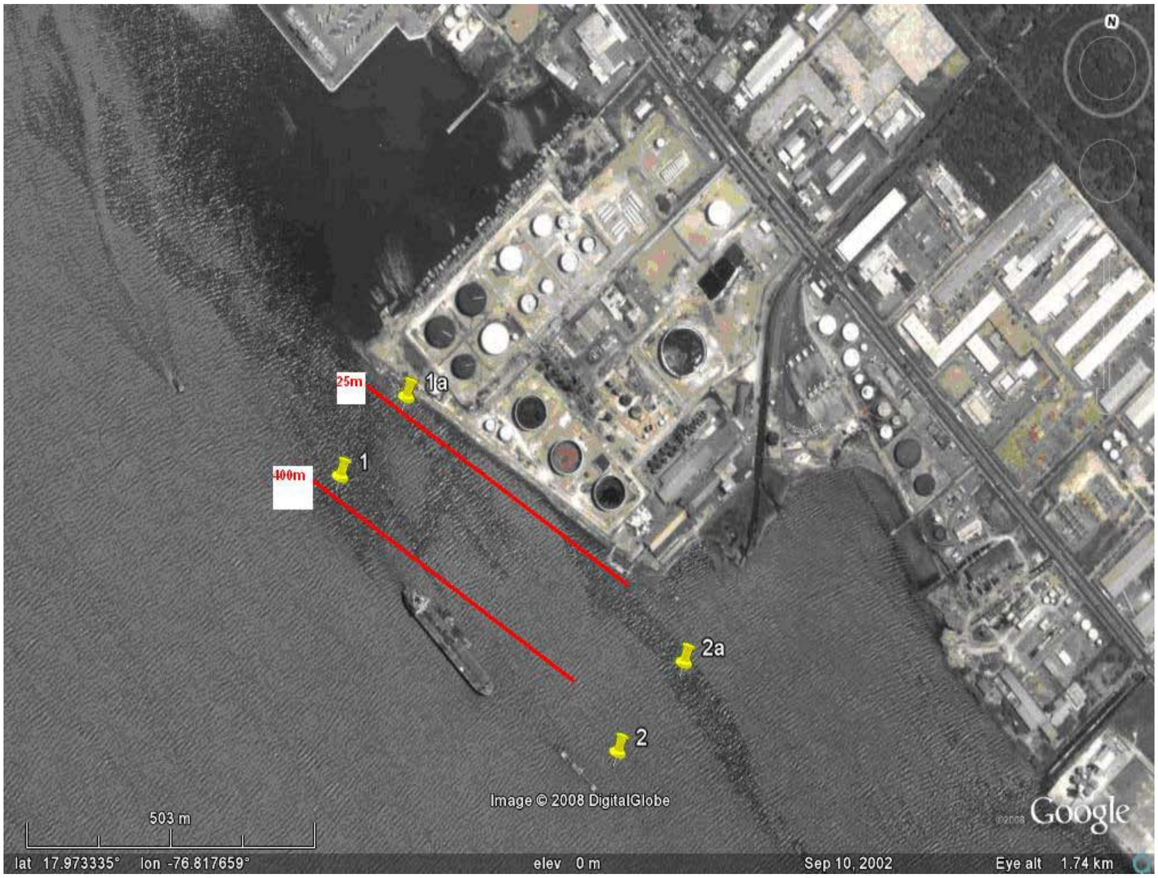
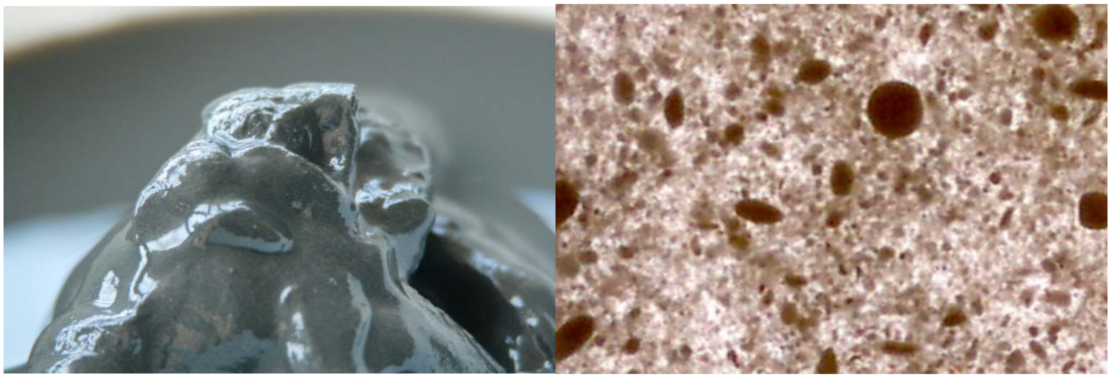


Figure 4-30 Samples of Sediments from Dives



Left to Right: The sediment taken from dive one, the same sediment viewed at X60

Anti-Clockwise from top left: The sediment from dive 2, the sediment viewed at X60, and tube worms found in the sediment

Sediment samples from Transect 2 contained calcareous sand with a small amount of grey silt similar to that found on the first transect.

The sand consisted mainly of shell fragments, as seen in the micrograph, tubeworms (including *Spiochaetopterus sp*.) were also collected in the sample.

Other organisms seen on dive 2 include:

- A yellow stingray *Urolophus jamaicensis*
- White spined green sea urchin *Lytechinus spp*.
- Bivalves
- Empty bivalve shells Eared ark (*Anadara notabilis*), Turkey Wing (*Arca zebra*) & White Semele (*Semele proficua*)

The substrates tended to change in composition from the muddy silt sampled on the west to the calcareous fragments sampled to the east. The presence of the mud was regarded as being the result of proximity to the Hunts Bay discharges, with increasing distances from this discharge (progressing eastward) resulting in less mud. Macro-algae were observed on any available hard surface. No fish were seen, presumably because of the turbid water.

Discussions with fishermen indicate that periodic migrations of shrimp into and out of Hunts Bay occur at least once per annum. The actual path of the migratory route is not known but it is possible that they move over the substrate immediately adjacent this facility.

4.3 SOCIOECONOMIC ASPECTS

4.3.1 Methodology

The socioeconomic impact assessment (SIA) examines the socio-economic setting of the study area and identifies potential impacts of the proposed development. The study area for the SIA includes the proposed site and areas within two kilometres (2 km) of the site. Any new development in a community will have local (micro), regional and national (macro) impacts. For the purpose of this SIA the local impacts will include the proposed site and the area within 2 km of the site. Regional impacts will be those at the Parish level while national impacts will be island wide.

The SIA included desktop research as well as a socioeconomic and public perception survey. The surveys were undertaken through personal interviews with community members, community organizations and available stakeholders.

The target population for the SIA was people residing within the study area (2km of the site). In order to determine the socioeconomic characteristics of the study area and public perception of the proposed development, a questionnaire survey was developed and administered through personal interviews. While personal interviews are noted to be associated with high costs and tend to be time intensive, they have the advantages of higher response rates and tend to be more favourable for open-ended questions. Uncertainty about the reliability of mail services in the study area also influenced the choice of survey instrument. Contact was made with the residents through consultations facilitated by the community development committees (CDCs). The consultations included an introduction to the project presented by Petrojam staff after which clarifications were given in response to questions. The residents were then interviewed individually for their perception of the project and some socioeconomic characteristics. A total of 110 interviews were conducted within four communities, Greenwich Town/Newport West (including the fishing beach), Tivoli Gardens, Rose Town and Whitfield Town. Representatives from the CDCs were also interviewed as well as other available stakeholders including the Kingston and St. Andrew Corporation (KSAC), Hope for Children Development Corporation (HCDC) and the Jamaica Public Service Company Ltd. (JPS).

The land use survey for this SIA included a review of satellite imagery of Jamaica and topographic maps. Field verification of land use was made during visits to the various communities.

4.3.2 Socioeconomic Setting

4.3.2.1 Demography

The population of the Parishes of Kingston and St. Andrew (KSA) was 663,600 at the end of 2006 (STATIN in ESSJ, 2007). This represents a 1.8% increase from the 2001 population of 651,900. The KSA has been characterized by slow growth rates as illustrated by annual growth rates ranging from 0.2 to 1.0% between 1970 and 2006 (Table 4-34). The Population Unit of the Planning Institute of Jamaica (PIOJ) has projected that the population for KSA will be 665,070 by 2010 and 695,917 by 2030. The male to female ratio in the 2001 census was 1:1.

It is important to note that while there has been an overall growth trend in the KSA population, Kingston's population has declined since 1970 (Figure 4-31) at rates of 0.1 and 0.7% per annum.

The SIA study area encompasses 17 communities [as defined by the Social Development Commission (SDC)] that falls within several enumeration districts. The 2001 population census indicated that the population of the communities within the SIA study areas was 84,347 (Table 4-35). The population within 0.5 km of the site was 8,891 while between 0.5 and 2 km had 75,456. Assuming annual growth rates of 0.2%, the population of the study area would be 85,877 in 2010, 87,611 in 2020 and 89,379 in 2030.

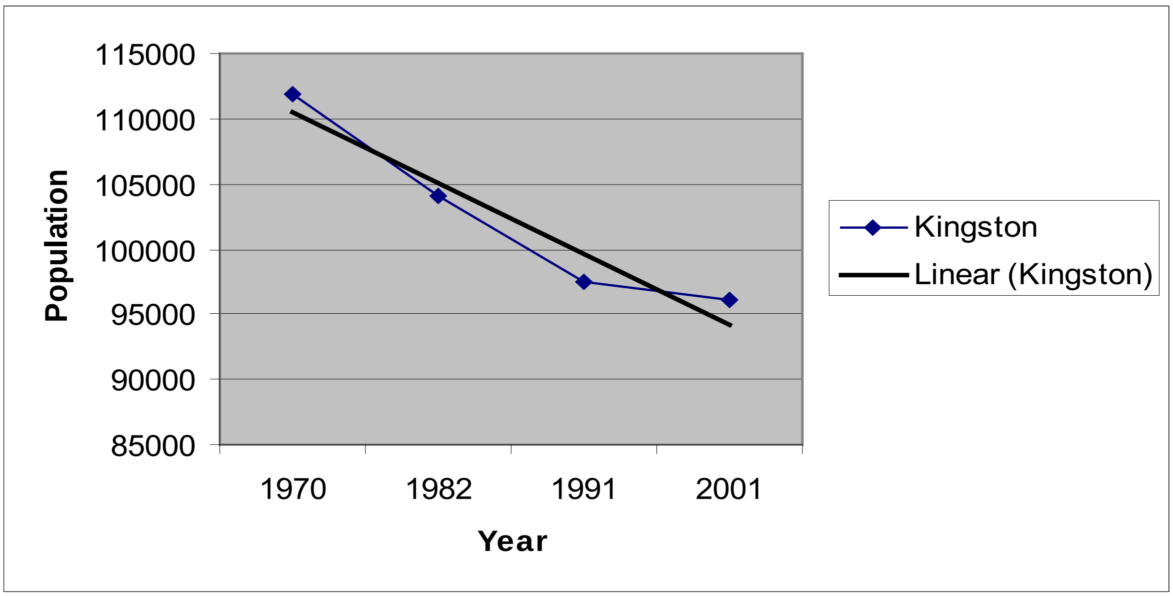
The socio-economic survey results indicated that the average household size within the SIA study area is 4 individuals with ranges from 1 to 11 persons per household. This average is consistent with that of the SDC which has prepared community profiles within the study area, but exceeds the national average of 3.3 (Jamaica Survey of Living Conditions, 2006). The figure also represents an increase from the 2002 Parish average of 3.2 (JSLC, 2002). Eighty four percent (84%) of respondents were the head of their households. Of these, 60% were males while 40% were females. The majority of the household heads were between the ages of 30 and 59, 17% were aged 18-29 years and 7% were over 60.

Table 4-34 Population for Kingston and St. Andrew 1970, 1982, 1991, 2001 & 2006

Year	Total	Males	Females	Intercensal Change%	Annual Rate of Growth%
1970	525,100	244,400	280,700	-	-
1982	586,900	274,800	312,100	11.8	1.0
1991	639,642	284,700	323,100	9.0	1.0
2001	651,880	300,546	339,098	1.9	0.2
2006	663,600	1,104,446	1,254,998		

Source: STATIN, Jamaica

Figure 4-31 Trends in the Population of Kingston 1970, 1982, 1991 & 2001



Source: STATIN, Jamaica

Table 4-35 Population of the Study Area by Communities (2001)

COMMUNITY	TOTAL	FEMALE	MALE
Arnett Gardens	1900	975	925
Central Down Town	1720	855	865
Delacree Park/Union Gardens	3171	1639	1532
Delacree Pen	15042	7774	7268
Denham Town	8344	4377	3967
Fletchers Land	714	366	348
Greenwich Town/Newport West	7561	3897	3664
Hannah Town/Craig Town	2883	1497	1386
Jones Town	5986	3121	2865
Maxfield Park	601	316	285
Newport East	1330	717	613
Rose Town	4061	2642	1419
Tivoli Gardens	4405	2352	2053
Trench Town	7006	3530	3476
West Down Town	3226	1665	1561
Whitfield Town	11586	6195	5391
Wilton Gardens/Rema	4811	2594	2217
TOTAL	84347	44512	39835

Source: STATIN, Jamaica

4.3.2.2 Infrastructure and Services

Transportation

The SIA study area has a network of roads that includes Classes A, B and C roads. The study site is located along Marcus Garvey Drive a "Class A' road which is one of the main routes into the Kingston city centre. Other major roads within the social impact study area include Spanish Town Road and Maxfield Avenue (Class A) and East Avenue (Class B).

Traffic data from the Ministry of Transport and Works showed that in February 2006, the total twelve hour (7 am to 7 pm) traffic count was 32,496 at the Marcus Garvey/Ninth Avenue intersection. The Twelve-hour traffic counts at other intersections along Marcus Garvey Drive in April 2005 were similar (32,541 at the Marcus Garvey/Fourth Avenue/Second Avenue intersection and 34,491 at Marcus Garvey/East Avenue intersection) (Ministry of Transport and Works, 2008). Marcus Garvey Drive was upgraded in 2008 by increasing the road width and changing traffic patterns.

Modes of Travel

Social impact survey results for the modes of travel to work or school were as follows:

Taxis	40%
Minibuses	23%

Own private vehicles	9%
Public transportation	24%
Other (walk, bicycle)	4%

Public transportation in the area is provided by the Jamaica Urban Transit Company (JUTC), mini buses and taxis. Some 24% of respondents indicated that their households walked to work and school. In addition to road transportation, 15% of respondents are Fisherfolk operating at the Greenwich Town Fishing Beach who use small boats.

Fifty-one percent (51%) of respondents indicated that they worked less than 1.6 km (1 mile) from their homes. Thirty three percent (33%) travelled between 1.6 km and 8 km (1 and 5 miles) to work, 14% travelled over 8 km (5 miles) and 2% travelled varying distances to work. Average weekly costs for transportation were estimated at $4,220 per household.

Health

The SIA study area is served by approximately 9 health centres and the Kingston Public and Victoria Jubilee Hospitals. Only one health facility - the Newport West Shipping Association Clinic, was reportedly located within 0.5 km of the site.

Schools

The SDC reported that approximately 83 schools were located within the SIA study area. Sixty five percent (65%) of these are Basic and Infant schools; 19% are primary schools, 11% are high schools and 5% are vocational schools. These schools fall within a much larger group of public schools listed on the Ministry of Education's 2006/07 Directory of Public Educational Institutions. The Directory lists 7 Infant, 18 Primary, 4 All-Age, 3 Primary & Junior High, 12 Secondary and 2 Technical High Schools within the Parish of Kingston (see Table 4-36). In addition, 1 Community College, 3 Teachers Colleges, a Multi-disciplinary institution and 2 Universities are listed within Kingston Metropolitan Area (KMA). A skills training facility, Garmex, which is operated by HEART Trust NTA is located close to the proposed project site on Marcus Garvey Drive.

The SDC Profile indicates that an average of 57.5% of household heads within the SIA study area reported that they had attained up to secondary level education. However, 68% of all residents reportedly had no academic qualifications. The communities are also characterized as having high levels of

Table 4-36 List of Schools in Study Area

Community	Schools			
	Basic	**Primary**	**High**	**Vocational**
Denham Town		Denham Town Primary	Denham Town High	
		St. Annie's Primary		
		St. Alban's Primary		
Tivoli Gardens	Charles Chinloy Basic		Tivoli Gardens High	
	Carnival Basic School			
	Operation Friendship Basic			
	Halibethian Basic			
	St. Annie's Infant			
	Kings Basic			
Trench Town	Boys Town Basic	Boys Town Primary	Charlie Smith High	
	Trench Town SDA Basic	Iris Gelly Primary	Trench Town High	
	Joy Town Learning Centre	Trench Town Primary		
	Albert Reid Basic			
	Victory Basic			
	Prophecy Basic			
	Grace Basic			
	Jamaica Confederation of Basic Schools			
	Bethel Basic			
	People's Church Basic			
	Bradford Basic			
Maxfield Park		Rousseau Primary	Norman Manley High	JAGAS/HEART
		Maxfield Park Primary		
Fletchers Land	St. Barnaba's Basic		Kingston Senior High	VOUCHE early childhood 1 year training course
	Hampden Basic			LEAP Centre
	St. Martin's Basic			
	Sylvia Foote Basic			
	Shiloh Basic			
Hannah Town/ Craig Town	St. John's Basic	Chetolah Park Primary	St. Annie's High	Mel Nathan/HEART Skills Training Centre
	Edith Dalton James Basic	Mel Nathan Prep		
Jones Town	Model Basic	Jones Town Primary		
	St. Simon Basic	Central Branch Primary		
	Jackson Basic			

Community	**Schools**			
	Basic	**Primary**	**High**	**Vocational**
	Jones Town Basic			
	His Majesty Basic			
	Advent Deliverance Basic			
	Central Branch Infant			
Whitfield Town	St. Peter Claver Basic	Whitfield Town All Age		
	Bethel Born Again Early Childhood	St. Peter Claver Primary		
	Barnes Basic			
	Ancient Restore Basic			
	Care Bear Basic and Pre-school			
	Carmel Early Childhood Development Centre			
	S-Corner Basic			
	Galilee Basic			
	Anderson Basic			
	St. Francis Basic			
	Western Basic			
	Beason Welsh Basic			
	Jahmona Basic			
	Life Tabernacle Early Childhood Development Centre			
	Crescent Road Church of God Basic			
	Pretoria Early Childhood Development Centre			
	Glady's Sheriff Basic			
Greenwich Town/Newport West	Blake's Basic	St. Andrew Primary	St. Andrew Technical High	
	Western Union Basic	Greenwich Town Primary		
	Jesus Christ Basic			

Source: SDC Profile

high-school drop outs and low levels of skills. This has implications for the impact of the project on these communities as the opportunities that may be available will require mostly highly skilled workers.

4.3.2.3 Housing

Tenure

In 2006 47.8% of households in the KMA lived in their own homes (JSLC, 2006). Thirty percent (30%) of households rented while 19.5% lived 'rent-free'. It is however important to distinguish between ownership of land and that of dwelling/housing. The JSLC only tracks ownership of dwelling and not land; therefore households may own their homes but not the land on which it is located.

Housing and land tenure data for communities within the SIA study area were obtained from the SDC. Housing data were available for only two communities, namely Denham Town and Greenwich Town/Newport West. Approximately 65% of the residents of Denham Town reportedly owned their houses (Table 4-37) compared with 9% in Greenwich Town/Newport West. Twenty eight percent (28%) of Denham Town residents lived "free" while 4.4% rented. On the other hand, only 7.5% of Denham Town residents reported owning the land on which their homes are located and 2.5% leased (Table 4-38). This implies that approximately 55% of residents may be squatting. In Greenwich Town/Newport West, 60% of residents reported renting their homes while 30% "captured" them and 10% own or lease their homes.

Land ownership ranged from 7.5% to 43% in selected communities. Other reported tenure types were rent, lease, family and capture. The SDC reported a total of 18 squatter settlements in four of the 17 communities within the SIA study area.

Construction Materials

The socioeconomic and perception survey results revealed that 70% of the houses within the SIA study area had outer walls constructed of block and steel, while 11% were constructed of wood. This is consistent with the 2006 JSLC figure for the KMA (74.2%) and the 2002 Parish figure for St. Andrew (75.5%), but higher than the 2002 Parish average for Kingston which was 47.4%. The most popular materials for roofs was zinc (54.5%) and concrete (10%) and for fencing were zinc (24.5%) and block and steel (14.5%). Nineteen percent of participants declined to respond to this question.

Table 4-37 Housing Tenure in the Study Area

COMMUNITY	Housing Tenure (%)				
	Own	Rent	Lease	Free	Capture
Denham Town	64.8	-	4.4	27.7	
Fletchers Land					
Greenwich Town/ Newport West	9	60	1	-	30

Source: SDC Profile

Table 4-38 Land Tenure in the Study Area

COMMUNITY	Land Tenure (%)						Squatting Settlements
	Own	Rent	Lease	Family Land	Capture	Other	
Denham Town	7.5		2.5				8
Fletchers Land	43	26	2	8			3
Hannah Town/Craig Town	42						
Jones Town	34				1	19	
Tivoli Gardens	39.6						6
Trench Town	40						
Newport East							1

Source: SDC Profile

4.3.2.4 Amenities

Access to amenities was deduced from a number of sources: the JSLC, the SDC Community Profile and the recent socioeconomic survey. In 2006, the main type of toilet facility in the KMA was flushed toilet (89.9% of households) and pit latrines (8.6%) (JSLC, 2006). For those households with no access to flushed toilets and pit latrines within the study area, the main means of disposal for faecal waste were by 'unorthodox methods' (SDC, 2008). Ninety percent (92%) of survey respondents had access to public water piped into their dwellings (64%) or yards (28%), a figure consistent with the 2006 JSLC figure for 2006 (92.4%). The main source of lighting for was electricity and the main source of fuel for cooking was liquefied petroleum gas (LPG). There was some access to fixed line telephones (36%) however, over 50% of respondents used mobile phones.

Solid Waste Disposal

The socioeconomic survey indicated that there was a regular solid waste disposal system serving the area. Approximately 93% of respondents had their garbage collected by garbage trucks operated by the National Solid Waste Management Authority (Metropolitan Parks and Markets). Three percent (3%) had private arrangements for garbage collection, while 3% burned their garbage. Seventy three percent (73%) of respondents had their garbage collected one to three times per week.

The National Solid Waste Authority (NSWMA) is the government agency with the mandate to regulate the solid waste industry in Jamaica. The NSWMA currently collects, treats and disposes of domestic solid waste. However, the NSWMA is not responsible for the collection, treatment or disposal of commercial, agricultural, industrial or hazardous waste.

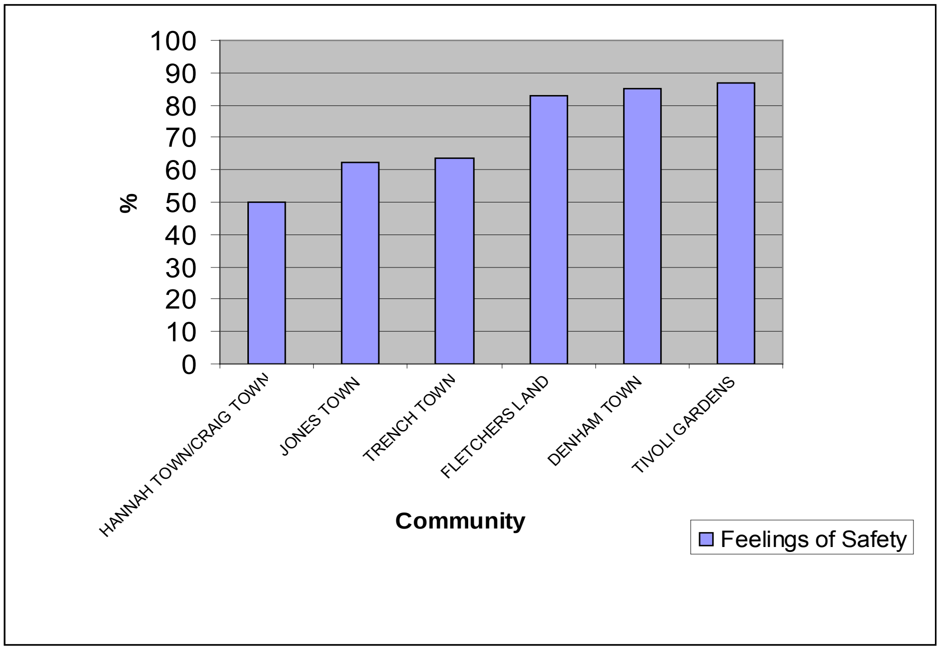
4.3.2.5 Community Fabric/Cohesion

Community fabric and cohesiveness is considered very strong within the communities in the study area although some communities have divisions within them. There is however little or no interaction between communities. The SDC community profiles indicate that there are active community-based organizations (CBOs), non-government organizations (NGOs), sports clubs and church groups in most of the communities within the study area. There are also numerous social interventions geared at skills training, maintaining peace, homework programs and community development. The majority of the communities also have a community centre that is in fair to good condition.

Petrojam has been engaged in community outreach activities within Greenwich Town. A Community Outreach Committee was established with representatives of the community and Petrojam staff. The work of the committee included evaluating and recommending the most cost-effective community related projects; developing appropriate projects and initiatives to enhance the well being of the community; identifying specific projects such as adopt-a-school, home work program etc. and making recommendations for consideration by Management. To date, one project was successfully completed, the community centre and basic school was upgraded in Greenwich Town. Petrojam provides two scholarships to high school students annually. Additionally, there is an annual health fair at Petrojam that is open to all residents within the surrounding areas.

Residents of many communities perceive crime as being low to moderate. This is reflected in the proportion of them indicating that they felt safe (Figure 4-32). Residents expressed moderate to high fear in two communities namely, Maxfield Park and Greenwich Town/Newport West. There was fear of gangs and warfare including reprisal killings and drive by shootings. Similar data were not available for remaining communities within the study area. The community liaison officer at the Hunts Bay Police Station was contacted for an interview but unfortunately it was not possible to conduct the interview.

Figure 4-32 Distribution of Residents Feeling Safe within their Communities



4.3.2.6 National Heritage Sites

The extent of the study area for the description of heritage sites is a radius of 0.5 km from the Petrojam site. The Jamaica National Heritage Trust indicated that there are no Historical Sites within the 0.5 km of the study site. However, there are numerous Heritage sites within the Parishes of Kingston and St. Andrew (Table 4-39).

4.3.3 Economic Activities

The SIA study area has a wide range of economic activities. The entire southern portion of the area consists of an industrial and commercial corridor which includes the Petrojam Limited Refinery (study site), Kingston Wharves and associated shipping terminals, warehouses and offices of brokerage firms, the Jamaica Public Service (JPS) Hunts Bay Power Plant and the Greenwich Town Fishing village among others. Economic activities within the residential communities are mainly small enterprises – shops and bars.

The Greenwich Town Fishing Beach is located immediately west of the study site. A 2002 study commissioned by Petrojam (ESL, 2002) indicated that there were an estimated 350 fisher folk operating from the fishing beach with 200 owning or controlling beach structures. At that time there were 218 structures on the beach, 72 of which were buildings and gear sheds belonging to the Fisheries Division. The 146 privately owned structures included 60% of which were “lived in” and 16% were shops and stalls for vendors, some of which were actually lived in. The remaining 24% (35 structures) were reportedly not lived in but were net- or boat/tackle-related structures. The estimated catch for the week was 100,000 lbs of fish with 112 active boats.

Table 4-39 JNHT Heritage Sites in Kingston and St. Andrew

Kingston		St. Andrew
Holy Trinity Cathedral		Plumb Point Lighthouse
Coke Methodist		Admiral Mountain Great House
Scots Kirk		Cherry Garden Great House
Wesley Methodist		Mona Great House
National Heroes Park		Craighton House
St. William Grant Park		Jewish Cemetery
Rockfort Spa		Cinchona Botanical Garden
Monument to the Rt. Excellent Sir Alexander Bustamante		Hope Botanical Garden
Monument to the Rt. Excellent Marcus Garvey		Clydesdale National Forest Park
Monument to the Rt. Excellent Norman Manley		Hollywell National Park
Monument to the Most Honourable Michael Manley		Nelson Mandela Park
Monument to the Rt. Excellent Nanny		Devon House
Monument to the Most Honourable Sir Donald Sangster		Jamaica College Buildings
Monument to the Rt. Excellent George William Gordon & the Rt. Excellent Paul Bogle		Mico College Buildings
Kingston Railway Station		Bob Marley Museum
Liberty Hall		Regardless
Admiralty Houses		24 Tucker Avenue
Negro Aroused		Blue Mountains
Ward Theatre		Papine-Mona Aqueduct
Fort Charles		Long Mountain
Port Royal Forts		Shortwood Teachers' College
Kingston Parish Church		Cherry Garden Great House
Port Royal Terrestrial Archaeology		Historic Half Way Tree Court House
Port Royal Underwater Archaeology		Church of the Good Shepherd
Tower Street - General Penitentiary		
Institute of Jamaica		

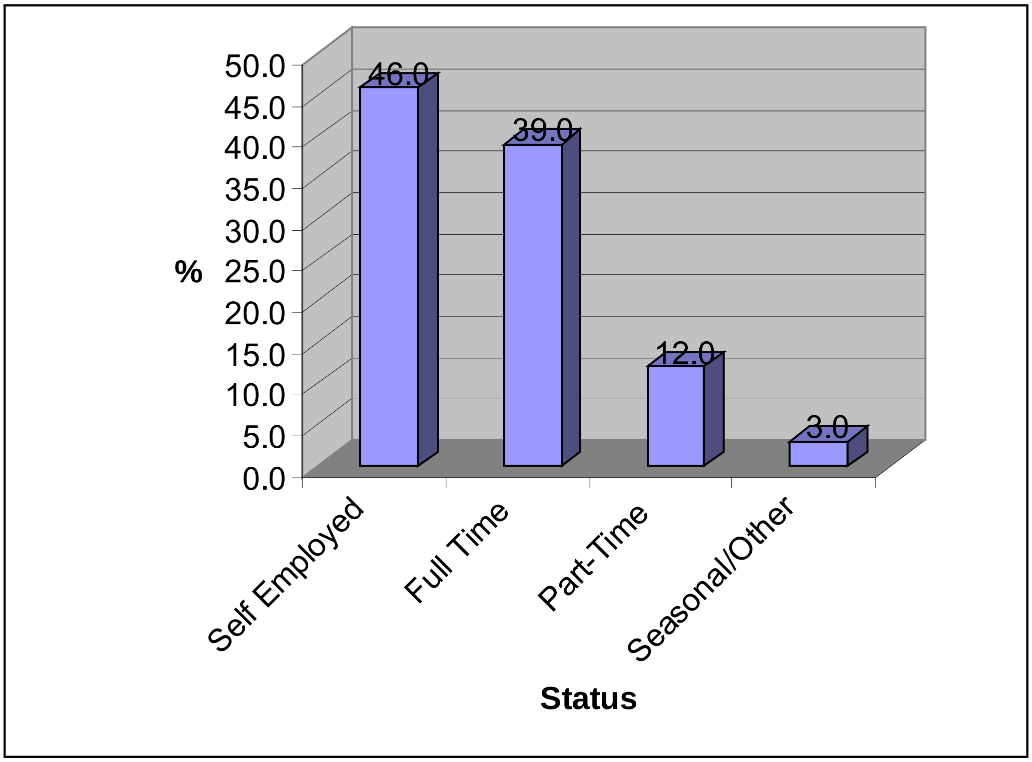
During the recent survey, there were fewer structures on the beach than was observed in 2002. This was largely due to the destruction of many by Hurricanes Ivan in 2004. Approximately 80 structures were observed, 62 of which were concrete gear sheds. The remaining were wood and zinc structures that were lived-in, shops or equipment sheds.

Employment and Income

Seventy five percent (75%) of the 110 participants surveyed reported being employed. Of those employed, 46% were self-employed, 39% full time, 12% part-time, while 4% had seasonal or other employment (Figure 4-33). The main occupation types included construction workers, business owners, fisher folk, vendors, shopkeepers, teachers, pastors and trade workers (painters, mechanics, tailors and dressmakers). Fisher folk accounted for the largest occupation type interviewed as a result of their concentration at the Greenwich Town Fishing Beach.

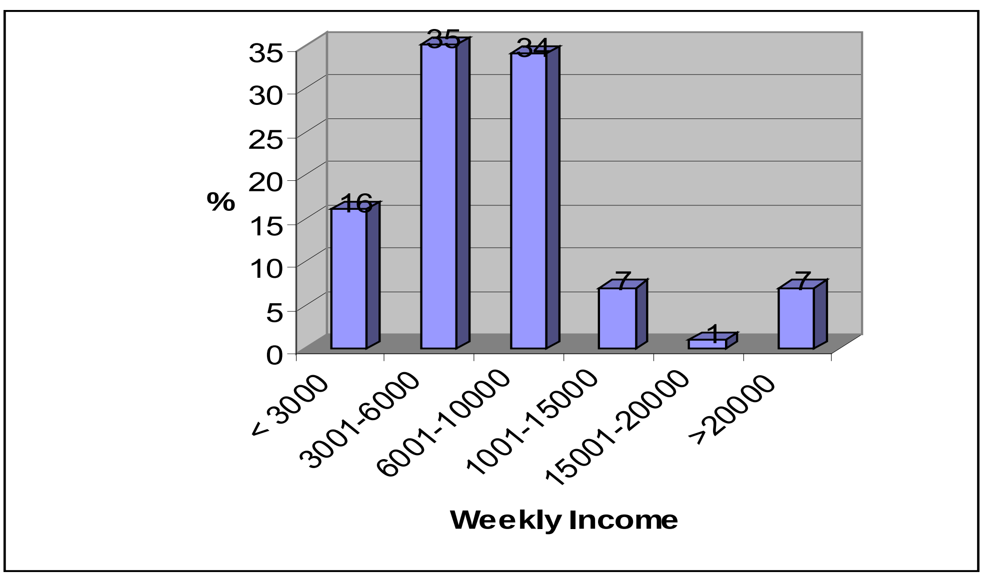
Sixty five percent (65%) of survey respondents agreed to give income information. Of these 69% reported earning $3,000-$10,000 per week, 16% less than $3,000, 8% earned $10,0001 - $20,000, and 7% over $20,000 (Figure 4-34). The survey findings are consistent with the SDC community profiles which identified high unemployment levels as a characteristic of the study area. The SDC survey reported 37% of household heads were unemployed. Among the youths (15-24), unemployment was reported at 40%. The high levels of unemployment may be related to the low skills level and educational attainment of the communities within the study area.

Figure 4-33 Distribution of Employment Status



Source: Socioeconomic Survey, 2008

Figure 4-34 Distribution of Income



Source: Socioeconomic Survey, 2008

4.3.3.1 Public Perception

The four stages used to determine public perception in this SIA were as follows.

- An initial public meeting to obtain feedback on the proposed TOR for the project;
- Interviews with members of various communities;
- Interviews with various stakeholders including community organizations; and
- Public meeting to present preliminary findings of the EIA.

Stages 2 and 3 are presented below. The public meetings were described in Section 3.

Community Interviews

Forty three percent (43%) of survey respondents indicated that they were aware of the proposed development. Of those that were informed, awareness was by word of mouth (31%) or electronic or printed media (19%), at the public meeting (44%) and other (6%). Over 70% of respondents believed that the project would have a positive impact on their communities (Figure 4-35).

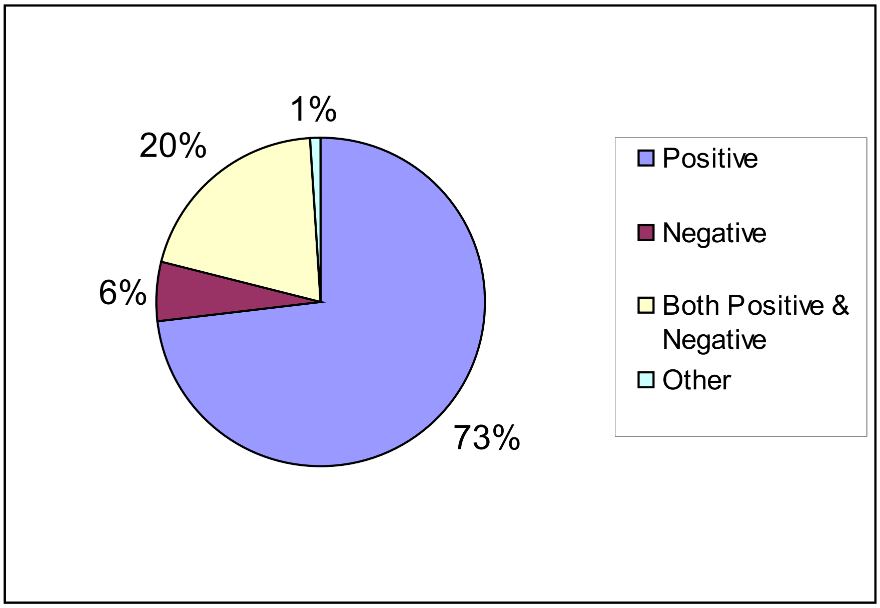
Almost 90% of respondents believed that the project would result in jobs for community members. Respondents had mixed feelings about impact on housing in the area. Twenty six percent (26%) believed it may foster new housing developments in surrounding communities while 17% thought it would have no impact. Many however commented that the housing impact would be through renovations and upgrades to existing structures as the area was not attractive for new developments.

Twenty four percent (24%) of respondents believed that the proposed project would result in increased exposure to air pollution, in particular dust. Twelve percent (12%) responded increased exposure to hazardous materials and increased illness (in particular respiratory illnesses) while 6% believed that there would be increased exposure to noise. It should however be noted that the non response rate for this question was 43% suggesting a low level of awareness of the environment.

Thirty seven percent (37%) of respondents believed that the proposed project would not have an impact on them personally. The perceived personal impacts were related to potential for employment, community development, increased health problems in particular sinus and other respiratory problems and negative impact on fishing which is a major livelihood activity in the study area.

The main comments from the communities were that the proposed development would be good for employment and training opportunities and would contribute to economic development in the area. They further commented that the opportunities should be made available in all communities within the area. The main concerns of the respondents were the possibility of the project not being implemented, and that if implemented that the people in the surrounding communities would not benefit. They were also concerned about the increased potential for exposure to hazards from the refinery and the lack of an emergency response programme or plan that fully engaged the community.

Figure 4-35 Perceived Impact of Proposed Refinery Upgrade Project on Communities



Stakeholders

Contact was made with the following key stakeholders through interviews, questionnaire or a staff survey to determine their perception about the project.

• Kingston and St. Andrew Corporation (KSAC)	Interview
• Hope for Children Development Company Limited (HCDC)	Interview
• Greenwich Town Community Development Committee (CDC)	Interview
• Tivoli Gardens CDC	Interview
• Rose Town Benevolent Society	Interview
• Whitfield Town CDC	Interview
• Jamaica Environmental Trust	Questionnaire
• Jamaica Public Service	Staff Survey

Results for these interviews are summarised below.

Kingston and St. Andrew Corporation (KSAC)

The Town Clerk for the KSAC and the Director of Planning were interviewed in an effort to obtain the KSAC's perception of the proposed project. The KSAC indicated that they were aware of the proposed project prior to TEMN's contact via correspondence from Petrojam to the KSAC. The KSAC felt that the proposed project would have a positive impact on surrounding communities as well as the entire country. Table 4-40 summarizes the KSAC responses to the perception questionnaire.

The KSAC commented that the negative impacts on health and the environment may be reduced through the use of appropriate technologies. The KSAC is also imploring the project implementers to follow the correct procedures for the approval process and ensure that local municipal laws are adhered to.

Hope for Children Development Company Limited

Hope for Children Company Limited (HCDC) is a child focused non-government organization (NGO) that operates in three of the communities within the SIA study area, namely, Greenwich Town, Rose Town and Whitfield Town. Its mandate is to improve the quality of life for children in extremely difficult circumstances. A perception survey was completed by Mr. Richard Troupe, Executive Director for HCDC and a member of the Greenwich Town Community Development Committee (CDC). Mr. Troupe indicated that he was aware of the proposed project prior to TEMN's contact and is of the opinion that the development would have a positive effect on the surrounding communities providing its execution has a high level of transparency, accountability and stakeholders' participation. He proposed that activities to sensitize the stakeholders should be a large part of the project. Table 4-41 summarizes the Mr. Troupe's responses.

Table 4-40 KSAC Response to Proposed Project

	Positive Impacts	Negative Impacts
Employment	Job creation	Given the culture of the surrounding communities, the positions for skilled labour may not be filled. Therefore there may be importation of labour. Loss of livelihood for Fisherfolk at Greenwich Town Fishing village if there is loss of fishing stock
Housing	-	-
Health and the Environment		Increased emissions from burn offs, exhaust stacks and increased traffic Destruction of coastline Destruction of fishing stock Increased generation of waste water Noise pollution
KSAC	KSAC and affiliate agencies such as the Board of Health must be a part of the process during and after construction	-

Table 4-41 Hope for Children Development Company Ltd. Response to Proposed Project

	Positive Impacts	Negative Impacts
Employment	Increased job opportunities in general but also specific to surrounding communities Provides a platform to leverage a win-win conversation and partnership with companies located within the industrial belt of Marcus Garvey Drive and surrounding communities Opportunity for persons without required skills set to access employment to be motivated to pursue skills training programme Consultations with direct beneficiaries and wider community to explore alternative livelihood options can be pursued to replace the fallout from the displacement of the Greenwich Town Fishing Village.	Displacement of the economic livelihood of fisher folks using the Greenwich Town Fishing Village Residents from the surrounding communities unable to maximize employment opportunity because of limited skills or community violence that might prevent/restrict the free movement of people
Housing	-	
Health and the Environment	The obvious due diligence taken to maximize adherence to safety policy and procedures at the plant must be seen as a strength of the company and its management The NEPA requirement of engaging community in the process of the plant upgrade offers an excellent opportunity for PETROJAM to critically address any long standing and possible emerging concerns of community residents. One can only hope that the outcome of the process will reduce the real or perceived health and /or environmental risk to communities.	Absence of a known emergency evacuation plan or warning systems should there be a problem at the plant Lack of an emergency warning system and evacuation plan for the community? The absence of frequent drills to ensure that community is mobilized to respond. Insurance coverage to protect life and property should the operations of the plant compromise either (for surrounding communities)
HCDC	A positive impact on the infrastructure of the community and the residents will directly improve HCDC capacity to realize its own mandate of improving the quality of lives of children. One can hope that the findings from the process of consultation and dialogue will provide useful information to guide short, medium and long term planning and development indices of the surrounding communities The upgrade project and the consultation process offer an excellent opportunity for partnership to be strengthened in the interest of community and national development.	

Mr. Troupe also commented that "Developers must exercise social and corporate responsibility to ensure the development is eco-friendly and recommends the adoption of a local Primary School to help improve the facilities". The CDC further stated that "stakeholders must make themselves available to answer burning questions at local consultation".

Greenwich Town Community Development Committee

Perception surveys were completed by Mr. Godfrey Lothian, President of the Greenwich Town Community Development Committee (GT CDC) and Football Club, and secretary of the GT CDC. The GT CDC indicated that they were made aware of the proposed project prior to TEMN's contact through communication with Petrojam and was of the opinion that the project would have a positive impact on the community providing community members are given the opportunity to gain employment. Table 4-42 summarizes the responses of the GT CDC.

The GT CDC stated that Petrojam is a major stakeholder of the community and commended Petrojam on their recent contribution of refurbishing the community centre. The GT CDC would like this relationship to grow with more interaction and joint projects between the community and Petrojam. They further commented that safety needs to be a key factor in order to protect the community and the environment.

Tivoli Gardens Community Development Committee

Mr. Donnavan Samuel, President of the Tivoli Gardens CDC (TG CDC) completed a perception survey for the proposed project. The TG CDC indicated that they were aware of the proposed project prior to TEMN's contact through their Member of Parliament, the Right Honourable Bruce Golding and a newspaper article. The TG CDC responded that the proposed project would have a positive impact on the community. When asked about impact within specific sectors of employment, housing health and the environment and the TG CDC, the following responses were given (Table 4-43).

The TG CDC commented that challenges may arise in finding the required skills sets within the community therefore; training may have to be facilitated for community members. The TG CDC also stated that they are confident that Petrojam "have the communities surrounding the plant best interest at heart and will put the necessary measures in place to protect them from any adverse impacts". The TG CDC however, noted that they would have preferred to hear about the project directly from the company.

Rose Town Benevolent Society

A perception survey was completed by Mr. Michael Black Chairman of the Rose Town Benevolent Society (RTBS). The RTBS indicated that they were aware of the proposed project prior to TEMN's contact by way of a televised broadcast. The RTBS believes that the project would be positive for the community. RTBS's perception of specific impacts is summarized in Table 4-44. The RTBS is imploring Petrojam to ensure that communities surrounding Petrojam get first preference for jobs as skilled persons exist in these communities and unemployment is high.

Table 4-42 Greenwich Town CDC Response to Proposed Project

	Positive Impacts	Negative Impacts
Employment	Create employment	
Housing	Employed persons may upgrade houses Conversion of zinc fences to concrete walls which is more aesthetic	
Health and the Environment		Increased risk of hazards such as fire in close proximity to the community
Greenwich Town CDC	Potential for joint projects between Petrojam and the community	

Table 4-43 Tivoli Gardens CDC Response to Proposed Project

	Positive Impacts	Negative Impacts
Employment	Provide jobs Reduced unemployment Motivation for persons to acquire appropriate skills to seek employment	-
Housing	Income stream will result in improvements to housing	-
Health and the Environment	New technology proposed will alleviate pollution problem currently being experienced such as particles in air breathing problems especially in immediate surroundings	Increased health risks if emissions are not controlled
TG CDC	The TG CDC may be able to facilitate or lobby for employment for community members Any improvement in the living standards of the community would be welcomed as the mandate of the TG CDC is to enhance the lives of community members	

Table 4-44 Rose Town CDC Response to Proposed Project

	Positive Impacts	Negative Impacts
Employment	Create jobs	Research by the JCF has shown that as income increases in some inner-city communities crime increases as there is cash flow to finance the acquisition of ammunition Workplace tension may increase when persons from various conflicting communities are employed in one place.
Housing	-	-
Health and the Environment	-	Increased risk for on-site workers
RTBS	RTBS may be able to identify persons within Rose Town that may qualify for employment	

Whitfield Town Community Development Committee

Mr. Charles Harvey, President of the Whitfield Town CDC (WT CDC) completed a perception survey. WT CDC indicated that they were unaware of the proposed project prior to TEMN's contact. However, it is believed that the project would be positive for the community. The WT CDC's perceived impacts on specific sectors are summarized in Table 4-45. The WT CDC commented that a good project should have a good environmental impact assessment and plan to minimize negative impacts on the community. The WT CDC also called for Petrojam to become more involved in community projects.

Jamaica Environment Trust

A perception survey was completed by the Jamaica Environment Trust (JET). JET indicated that based on the project information that they reviewed, "the refinery upgrade will be beneficial to the environment as part of what is motivating the refinery upgrade is the goal of making cleaner, low-sulphur fuels (gasoline and diesel). That alone will help to improve air quality across Jamaica". JET however noted that "the real extent of how much, if at all, this project will benefit the environment will emerge in the details provided in the EIA: what pollution control technology the upgraded facility will use and how the residual air and water pollution would impact air and water quality, respectively". JET further commented that they are looking forward to seeing the full EIA with "a thorough assessment of all pollution control alternatives that are available to Petrojam and a full, quantitative assessment of the air and water quality impacts of the facility before and after the upgrade".

Jamaica Public Service (JPS)

Perception surveys were completed by 13 JPS staff members at the Hunts Bay Power Plant which is located adjacent to the subject site. This represents 19.4% of the station's employee population. The survey was administered to a wide cross section of employees. All respondents were aware of the proposed project prior to TEMN's contact, 39% from television, 31% from multiple sources and 15% from the public meeting. Almost 70% of the respondents thought the project would have a positive impact on the surrounding communities, 8% thought it would be negative while 15% thought it would have both negative and positive impacts.

The positive impacts included job creation (84%), an increasing in the number of persons who will be able to afford housing with employment (15%), reductions in the emission of contaminants such as sulphur into the atmosphere and more environmentally-friendly products (31%). The negative impacts given included increased health risks such as respiratory problems (23%) and increased emissions (23%). The main perceived impact on the company was the availability of cheaper, cleaner and more diversified fuel for electricity generation which will result in reductions in costs. The staff commented that they hope that the project will be implemented successfully and not be "another project in the pipeline" as there will be economic gains for the country. More raw materials will become available to local companies which will retain foreign exchange in the country. The new product petcoke will also be very beneficial as it will result in reductions in electricity costs. The staff recommended that more public education activities be conducted to make the public more aware of the operations of Petrojam and its impacts (positive and negative) on society.

Table 4-45 Whitfield Town CDC Response to Proposed Project

	Positive Impacts	Negative Impacts
Employment	Employment opportunities	Small pool of skilled persons
Housing	Upgrading of houses	
Health and the Environment		Increasing pollution may impact fisher folk Spills from increase activity
RTBS	Opportunity to form partnership with Petrojam for social interventions within the community	Community members may not gain employment

One of the impacts of the project identified by JPS staff is the "availability of cheaper, cleaner and more diversified fuel for electricity generation". This is in reference to a new product that will be produced as a result of the upgrade of the refinery – Petroleum Coke (petcoke). Petcoke is used to generate electricity and has the advantage of a high heating value which gives petcoke an advantage since less petcoke is used to produce the same unit of electricity than most other fuel types. The main benefit of Petcoke is its cost since it is a by-product of another process, and hence the cost of production favourable relative to other fuels.

Petrojam, the JPS and the Ministry of Energy, in July 2008 signed a "letter of intent" for the development of a Petcoke Cogeneration Power Project at the JPS Hunts Bay Plant. The JPS reported that the plant will generate 100 MW or one-sixth of the power needed by JPS customers, via the national grid, while another 20 MW will be provided to the upgraded Petrojam Refinery.

In an article published by the Jamaica Gleaner on July 23, 2008 (Myers, 2008), the Chief Executive Officer (CEO) of JPS, Mr. Damian Obiligo stated that the use of petcoke for electricity generation will result in a 5% reduction in the cost of generating electricity in Jamaica. There will also be reduction in oil imports. The reduced costs will be passed on to customers in reduced electricity bills. The report further stated that the construction of Cogeneration Plant would cost $21.6 billion (US $300 million).

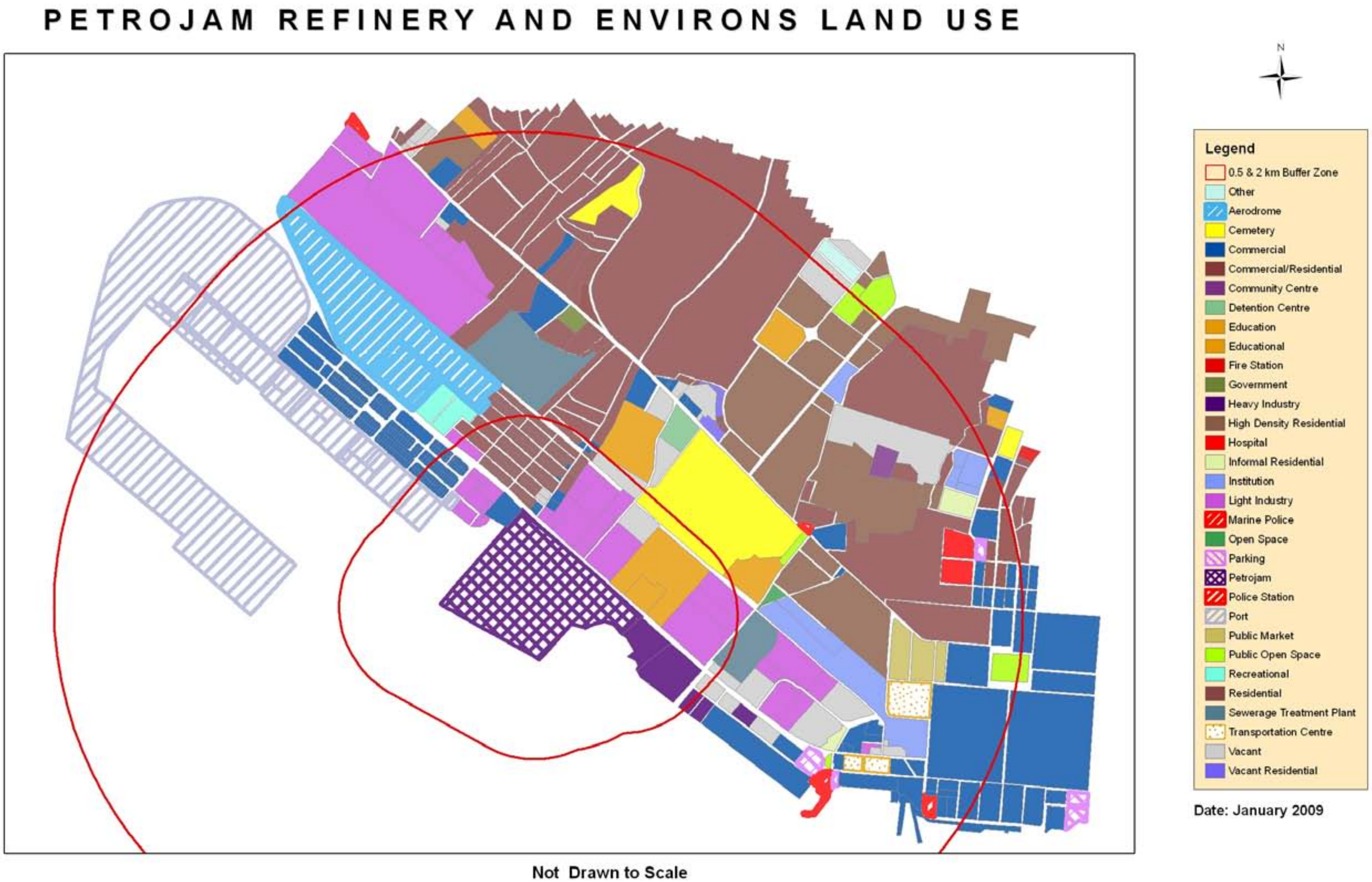
4.3.3.2 Land Use

The land use in the vicinity of the site is illustrated in Figure 4-36.

On-site

The site is located on the south side of Marcus Garvey Drive and consists of an oil refinery and an ethanol plant. Onsite are also a parking lot, storage tanks, a gasoline station and administrative buildings. A gully (Shoemaker Gully) traverses the eastern portion of the site, beyond which are additional storage tanks, the loading area and an out-of-use office building.

Figure 4-36 Land Use Map of the Study Area



Within 0.5km of the Site

The lands within 0.5km of the site include the inner portions of the Kingston Harbour. The Greenwich Town Fishing Village is located immediately west of the site, beyond which are commercial and light industrial facilities. The lands to the north and east include heavy industrial, light industrial, commercial and residential. The facilities include an Esso Service Station, Jamaica Public Service Hunts Bay Power Plant, T. Geddes Grant Ltd. and Ministry of Agriculture Export Division.

Within 0.5 km – 2 km of the Site

Lands within 0.5 km-2 km include the Kingston Harbour to the south, the Down Town Kingston area to the east, the communities of Whitfield Park and Delacree Pen to the north and the Port to the west. Land use within this area is very dense with a wide cross section of uses. The western portions are mainly commercial with some residential and light and heavy industrial. Lands to the north are mainly residential communities with commercial and open spaces. Several schools, a cemetery and other government facilities are also located within this area. The lands to the west are commercial, light industrial and an aerodrome. Some residential areas are also located within this area (see Figure 4-36).

4.4 MACROECONOMIC PERSPECTIVES

Jamaica's economic development is inextricably tied to its appetite for and the efficiency with which it uses energy. The development process invariably means that the demand for energy usually increases. Jamaica's economy has been almost entirely dependent on imported petroleum as its primary source of energy, accounting for 95% of total energy consumption in 2006 (ESSJ 2007). This pattern of consumption has resulted in the country's oil bill ballooning from approximately US$323 million in 1998 to over US$2 billion in 2007. Of the US$2 billion bill, 36% was for the importation of refined petroleum products. The consumption pattern has also resulted in the country having one of the highest energy intensity rates in Latin America and the Caribbean (about 10.2 barrels per capita). The bauxite and alumina industry is the largest consumer of petroleum in the Jamaican economy, accounting for 37% of the total petroleum consumption (in 2006): the transport sector was the second largest (31%), while electricity generation accounted for 25%.

Although there has been some reprieve, the effects of the recent surges in oil prices have negatively impacted the Jamaican economy and the social well-being of its people. Additionally, the consumption of petroleum products globally has fuelled environmental concerns in particular as they relate to climate change.

Climate change has negative implications for Jamaica, a small-island developing state. The effects have already been seen in the increasing frequency and intensity of weather systems such as tropical storms and hurricanes which inflict billions of dollars in damages and losses especially to coastal areas. In response to these environmental concerns, several international conventions such as the Kyoto Protocol (to which Jamaica is a signatory) are attempting to secure voluntary commitments to reduce global greenhouse gas emissions from energy related and other activities. There have also been some important technological advances designed to minimize adverse environmental impact. Of immediate concern is the need to continue putting in place measures that will reduce the vulnerability to hurricanes and in the longer term to protect coastal assets and/or otherwise mitigate the longer term impacts of climate change.

The Green Paper: Jamaica Energy Policy 2006-2020

The following are the key objectives of the Jamaica Energy Policy 2006-2020 (Green Paper):

- Ensure stable and adequate energy supplies at the least economic cost in a deregulated and liberalized environment to enhance international competitiveness and to improve quality of life of householders;
- Protect the economy from the volatility in energy prices which has been experienced with petroleum fuels and which will continue as oil supplies become more limited; and
- Minimize the adverse environmental effects and pollution caused by the production, storage, transport and use of energy, and minimize environmental degradation as a result of the use of fuel wood

The recommendations to achieve the objectives of the policy include strengthening bilateral relationships with energy suppliers in the region; and revision of existing regulations to make provisions that will ensure adequate inventory levels exist to cushion any short-term disruptions in supply, and to increase energy security and supply. Another recommendation was related to Petroleum refining capacity. The Policy stated that the government was committed to preserve the value-added benefits from the state-owned Petrojam refinery (study site) which contributed 2% to gross domestic product (GDP) in 2005. The policy also highlighted the need to improve the capacity and efficiency of the refinery.

The refinery upgrade will directly address these policy recommendations since it will:

- Increase the capacity of the refinery
- improve the energy security by providing more flexibility in the provision of finished petroleum product
- reducing the dependence on suppliers finished petroleum products
- increase the value added benefit of the refinery by producing larger quantities of higher value products
- produce Pet Coke as a by product which will be used for electricity generation

Draft Energy Sector Plan, National Development Plan - Vision 2030

The Draft Vision 2030 Jamaica, National Development Plan provides the blueprint for Jamaica's strategic development aimed at putting Jamaica in a position to achieve developed country status by 2030. It presents the goals, outcomes, strategies and actions, and the implementation, monitoring and evaluation framework that will lead the country to sustainable prosperity by 2030, within the context of the country's economic, social, environmental and governance structures. The plan was developed through 27 sectoral task forces including the Energy Sector Task Force.

The draft Energy Sector Plan while indicating the need for energy diversification stated that "it is highly likely that fossil fuels will remain the main source of energy for Jamaica over the planning horizon to 2030. The Sector Plan further stated the need to upgrade the Petrojam refinery to increase capacity utilization and output of lighter and higher-value refined petroleum products in order to replace imports and compensate for the potential switch from oil-fired to natural gas power plants. The plan also calls for the production of pet coke as a by product that will be produced in the upgrade of the Petrojam Refinery.

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5 POLICY, LEGISLATIVE AND REGULATORY REGIME

5.1 RESPONSIBLE AUTHORITIES

The responsibility for regulating and facilitating environmentally sound development lies with several authorities. The principal agency responsible for environmental matters is the National Environment and Planning Agency (NEPA) which now falls under the Office of the Prime Minister. This agency administers the Natural Resources Conservation Authority Act (1991), which allows the Natural Resources Conservation Authority, the Board to which NEPA reports, to request an environmental impact assessment in addition to the requirements of the Permit and Licensing System for development or construction considered likely to have an adverse effect on the environment. Failure or refusal to submit the documents is an offence under the law. This agency also administers the Beach Control Act under which a License is required for encroachment on the foreshore, such as the development of a pier. Petrojam has applied for a Permit as well as a Beach Control Licence from NEPA and this Environmental Impact Assessment is required by NEPA to fulfil the requirements for processing this application.

The Environmental Health Unit (EHU) of the Ministry of Health and Environment administers the Public Health Regulations (1976). A full application for approval of sewage treatment plans may be made to the EHU, which will input into the detailed application to be approved by the NRCA before authorizing any development. The EHU and local planning authorities monitor construction work to ensure that all development restrictions and requirements are properly adhered to.

The Water Resources Authority (WRA) administers the Water Resources Act under which groundwater wells are licensed and monitored.

In addition, there are Parish Acts and guidelines of local significance, including the Local Improvements Act (1944). However, whereas general approval under the Parish Councils Act is needed for building permits, the UDC Act supersedes all other legislation in the UDC designated areas. The construction of all buildings must comply with the Building Code. The Ministry of Health and Environment and the Town Planning Department have manuals (developed by ASCEND, 1996) which provide guidelines and planning standards for housing developments. The national planning enforcement authority is the Town and Country Planning Authority (TCPA) which is now part of the NEPA.

Petrojam’s operations require compliance with legislation in several areas and their activities are also relevant to several government policies and plans as well as to the fulfilment of Jamaica’s obligations under several international treaties.

The various instruments (i.e., legislation, policies and international treaties) are described in the remainder of this section.

5.2 PLANNING AND ENVIRONMENTAL LEGISLATION

5.2.1 Natural Resources Conservation Authority Act (1991)

The Natural Resources Conservation Authority Act provides for the management, conservation and protection of the natural resources of Jamaica. The Act establishes the Natural Resources Conservation Authority, a body of persons appointed by the Minister. The functions of the Authority include the taking of such steps that are necessary to ensure the effective management of the physical environment of Jamaica; and the management of marine parks and protected areas. Section 9 of the Act creates a Ministerial discretion to declare parts of or the entire island a 'prescribed area', in which specified activities require a permit, and for which activities an environmental impact assessment may be required. The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order, 1996 and the Permits & Licensing Regulations was passed pursuant to section 9 of the Natural Resources Conservation Authority Act, 1991. The Order provides that the entire island of Jamaica is a prescribed area and lists specified categories of enterprise, construction or development that require a permit.

The provisions of the NRCA Act apply to this development and would ensure that proper environment and planning considerations are taken into account in the upgrade of the refinery. A permit to operate is required by any new development, construction or modification of any works enabling the discharge of trade or sewage effluent into the environment under Sections 9 and 12 of the NRCA Act. Licences will also be required for existing establishments which discharge sewage and trade effluent.

5.2.2 The Petroleum Act (1979)

The Petroleum Act allows the Petroleum Corporation of Jamaica to acquire, construct, maintain, manage or operate any refining or processing facilities. Regulations governing this Act include:

- "Ensuring safe construction, maintenance and operation of installations and facilities used in connection with operations related to petroleum resources…"
- " the prevention of pollution and the taking of remedial action in respect of any pollution which may occur"
- "Providing for the protection of fishing…and other activities….. in vicinity of areas of operation…"

5.2.3 The Watershed Protection Act (1963)

The Watershed Protection Act (1963) was enacted to provide protection for watersheds and adjoining areas and by that means promote the conservation of water resources. The Watershed Protection Commission, established by the Act, can make relevant regulations restricting the planting of crops, the felling and destruction of trees, and the clearing of vegetation within watershed areas. The Petrojam site falls within the Hope River watershed. The abstraction of water from wells on and near the Petrojam site and general hydrology related impacts will be evaluated in terms of the water resources for the Hope River watershed.

5.2.4 The Town and Country Planning Act (1975)

The strategic plans for area development are TCPA formulated and coordinated in the form of Development Orders consistent with the Town and Country Planning Act (1975). This act is now administered by NEPA, and the NRCA board functions as the Town and Country Planning Authority.

5.2.5 The Beach Control Act (1956)

The Beach Control Act (1956) states that no person shall be deemed to have any rights in or over the foreshore of the island or the floor of the sea and all rights over the foreshore of the island and the floor of the sea are declared to be vested in the Crown. Additionally, no person shall encroach on or use, or permit any encroachment on or use of, the foreshore or the floor of the sea for any public purpose or for or in connection with any trade or business, or commercial enterprise without a licence granted under this Act. This act is administered by NEPA.

This piece of legislation that was passed to ensure the proper management of Jamaica's coastal and marine resources by a system of licensing of activities on the foreshore and the floor of the sea. The Act also addresses other issues such as access to the shoreline, and other rights associated with fishing and public recreation, as well as the establishment of marine protected areas. It is currently undergoing substantive review to address more contemporary legal and management issues including the expansion of the Judge's discretion on sentencing, an increase in fines and the introduction of valuing natural resources based on defined criteria.

5.2.6 Occupational Health And Safety Act, 2004 (Draft)

This Act is in Draft form and is likely to contain the following provisions:

- Establishment of Joint Health and Safety Committees at workplaces
- Establishment of a work trades committee
- Establishment of an Advisory Council
- Establishment of schemes of monetary contributions of employers
- Sets out the duties of employers (including owners and employers at construction sites) and suppliers
- Requirements for providing information on and for the safe use of hazardous chemicals
- Empowering the Minister to make regulations under the Act

It should be stressed that this Act is only in Draft form and it is not appropriate to specify the details of the provisions.

5.2.7 Public Health Act (1985)

The Public Health Act (1974), last amended in 1996 provides the legal framework for the protection of public health. It includes provisions for the establishment of a Central Health Committee and local boards of health. The Act empowers the Minister to make regulations in relation to various health related matters but also includes provisions for making regulations concerning air and soil pollution, occupational diseases and employment health hazards. Relevant regulations are the Public Health (Nuisance) regulations and the Public Health (Garbage Collection and Disposal) regulations.

The Public Health (Nuisance) regulations of 1995 made under the Public Health Act include “dust, smoke, fumes, gases or effluvia” among the nuisances that persons are prohibited from causing or permitted to be caused. The regulations also empower a Medical Officer (Health), a public inspector or person authorised by the Minister (of Health) to require owners to abate the nuisance “within a reasonable time not being more than three days as may be specified in the notice”.

The Public Health (Garbage Collection and Disposal) regulations make reference to hazardous waste. The regulations define “hazardous. toxic or noxious garbage" as “garbage which is classified by the Local Board and the Authority or the Water Resources Authority to be detrimental to (a) the health or safety of the public; (b) animals; or (c) the environment.

5.2.8 Petroleum and Oil Fuel (Landing & Storage) Act (1925)

This act defines the nature of petroleum fuels that can be imported and specifies how petroleum fuels must be stored and provisions for licensing persons who deal or petroleum.

5.2.9 Factories Act (1943)

The Factories Act:

- Empowers the Chief Factory Inspector to register factories (including docks and wharfs) and to periodically renew the registration provided safety and other conditions are met and empowers the Chief Factory Inspector and Inspectors appointed under the Act to enter premises for inspection
- Requires premises to be used as factories or modification to factories to have the approval of the Chief Factory Inspector before seeking approval of the appropriate Building Authority (in Petrojam’s case the KSAC)
- Requires factory operators to file annual reports describing any changes or alterations of the factory and to notify the Chief Factory Inspector of any accidents or industrial diseases
- Empowers the Minister to make regulations under the Act to ensure the health, safety and welfare of employees and of machinery
- Establishes a Factories Appeals Board (appointed by the Minister) to hear and determine appeals of the decisions of the Chief Factories Inspector

5.2.10 The Harbours Act (1874)

This Act allows the Marine Board to make rules for the regulation and control of any harbour in the Island and of the channels and approaches leading thereto and of persons, boats and vessels using such harbour or approaches, and for all purposes connected with any such matters. According to the Act, the duty of the Harbour Master includes all matters relating to maintaining and protecting the harbour and shipping channels

5.2.11 The Wildlife Protection Act (1945)

This Act is primarily concerned with the protection of specified species of fauna. It prohibits the removal, sale, or possession of protected animals and the use of dynamite, poison or other noxious material to kill or injure fish. This Act has undergone review particularly in the area of increased fines and the number of animals now enjoying protected status. Further amendments are being undertaken to address a variety of other issues relating to the management and conservation of these natural resources and the inclusion of flora.

Although the Act also prohibits the discharge of trade effluent or industrial waste into any harbour, stream, river canal etc., in practice, the Wildlife Protection Act has been superseded by the NRCA Act which provides for permits or licences for the discharge of trade effluent into waters. There are also Draft Trade Effluent and Sewage Regulations that would be promulgated under the NRCA Act and these regulations would incorporate draft trade effluent standards which specify limits for discharges of trade effluent and draft ambient water quality Standards.

5.2.12 The Water Resources Act (1995)

The Water Resources Act (1995) was promulgated in the Jamaican Parliament in September 1995 and enacted into law on 1st April 1996. The act authorises the Water Resources Authority to collect, compile, store and disseminate data concerning the water resources of Jamaica, hence facilitating the planning regulating, conservation, allocation and management of these resources. The Act also requires that any abstraction, or the development of facilities to abstract water is subject to the requirement of a Licence issued by the Authority, unless the applicant has right of access to the water resource and the abstraction is required only for domestic use.

5.2.13 The Fishing Industry Act (1975)

The Fishing Industry Act 1975 is at this moment still the main piece of legislation that provides for the regulation of the fishing industry in Jamaica. A Licensing Authority, in practice the Director of Fisheries, is empowered by the Act to issue licences, and is required to keep a register of all licences issued. In addition to the licence to fish, every boat used for fishing whether for business, recreation or sport, must be registered under the Act and the owner of the boat must possess a licence authorizing the boat to be used for fishing.

The Act, however, has not kept pace with the evolution of fishing and the attendant resource management issues, and in this regard, a new Act which will provide an institutional framework for the management, planning, development and conservation of fisheries resources in Jamaica is scheduled to be passed soon.

5.3 Other Significant Legislation and Policies

Other significant legislation includes the Tree Preservation Order which provides for the protection of all trees from destruction or mutilation of any kind, except with the express permission of the local planning authority.

5.3.1 National Land Policy (1996)

This policy establishes the framework to enhance the efficient planning, management, development and use of land. It is comprehensive in order to achieve complementary and compatible development which is in harmony with economic and socio-cultural factors.

Chapter 3 of the National Land Policy includes rural development and the protection of watershed and fragile areas, exploitation of mineral resources, and crop and livestock production.

5.3.2 National Industrial Policy (1996)

This policy was developed against a backdrop of a changing global economy and the need for Jamaica to rise to the attendant challenges, in this context to implement its stated commitment to a market led economy. The policy however recognizes that industrialization carries with it economic and social implications, that industrial activity may necessitate the exploitation of natural resources, but that the pursuit of economic development cannot be in isolation of the need for environmental protection and management. The sustainable use and management of the environment becomes a critical component of the policy.

5.3.3 Jamaica Energy Policy (2006 - 2020): Green Paper

The main objectives of the energy policy are as follows:

- ensure stable and adequate energy supplies at the least economic cost in a deregulated and liberalized environment to enhance international competitiveness and to improve quality of life of householders;
- provide an appropriate environment conducive to private sector participation in electricity generation;

- make electricity available to the remaining areas of the island, especially in deep rural areas and at affordable rates to lifeline customers;
- diversify the energy base and encourage the development of indigenous energy resources where economically viable and technically feasible; and ensure the security of energy supplies;
- protect the economy from the volatility in energy prices which has been experienced with petroleum fuels and which will continue as oil supplies become more limited;
- encourage efficiency in energy production, conversion and use with the overall objective of reducing the energy intensity of the economy;
- complement the country's Industrial Policy recognizing the importance of energy as a critical input to industrial growth and stability;
- minimize the adverse environmental effects and pollution caused by the production, storage, transport and use of energy, and minimize environmental degradation as a result of the use of fuel wood; and
- establish an appropriate regulatory framework to protect consumers, investors and the environment.

5.3.4 Policy For the National System of Protected Areas (1997)

Jamaica has a rich and diverse natural heritage created by its geographical location and its varied topography, geology and drainage. That diversity endowed the island with a scenic beauty sought after by Jamaicans and visitors. In the face of deteriorating environmental conditions, a system of protected areas provided the means to conserve and ensure the sustainable use of Jamaica's biological and cultural resources. The Palisadoes peninsula, its surrounding waters with mangroves and seagrass meadows and the adjacent Port Royal Cays and coral reefs comprised an ecological complex of significant social and economic value to Jamaica. That area was designated a protected area in September, 1998.

5.4 Relevant International Treaties

Specially Protected Areas and Wildlife (SPAW) Protocol encouraged the establishment of protected areas to conserve rare and fragile ecosystems and habitats.

Cartagena Convention was an international treaty signed by all Caribbean nations, obligating them to marine pollution monitoring and control of ship borne and land based sources of hydrocarbon (oil) pollution.

The Earth Summit Treaties signed by Jamaica at the UN Conference on Environment and Development including Agenda 21, the Biodiversity Convention, and the United Nations Framework Convention on Climate Change, the UN Conference on Small Islands Developing States, the UN Convention on the Convention on the Law of the Sea, the London Convention on the Prevention of Marine Pollution, all obligate Jamaica to take wide ranging measures in environmental protection and sustainable development, including enacting over-riding legislative authority in environmental matters to the Ministry of Health and Environment.

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years.

The International Convention for the Prevention of Pollution from Ships (MARPOL) was adopted on 2 November 1973 at IMO and covered pollution by oil, chemicals, harmful substances in packaged form, sewage and garbage. The Protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol) was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a spate of tanker accidents in 1976 - 1977. (Measures relating to tanker design and operation were also incorporated into a Protocol of 1978 relating to the 1974 Convention on the Safety of Life at Sea, 1974).

As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument is referred to as the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), and it entered into force on 2 October 1983 (Annexes I and II).

The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes.

The International Ship and Port Facility Security Code (ISPS Code) is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities in the wake of the 9/11 attacks in the United States.

The ISPS Code is implemented through chapter XI-2 Special measures to enhance maritime security in the International Convention for the Safety of Life at Sea (SOLAS). The Code has two parts, one mandatory and one recommendatory.

In essence, the Code takes the approach that ensuring the security of ships and port facilities is a risk management activity and that, to determine what security measures are appropriate, an assessment of the risks must be made in each particular case.

The purpose of the Code is to provide a standardised, consistent framework for evaluating risk, enabling Governments to offset changes in threat with changes in vulnerability for ships and port facilities through determination of appropriate security levels and corresponding security measures.

6 IDENTIFICATION AND ASSESSMENT/ANALYSIS OF POTENTIAL IMPACTS

6.1 METHODOLOGY FOR IMPACT ASSESSMENT

An assessment of the overall project alternatives and analyses of the potential environmental and social impacts during construction and after the upgrade are presented in this section.

The environmental impacts specified in the Terms of Reference can be grouped into four components (study disciplines), namely:

- Physical/Chemical,
- Biological/ecological,
- Sociologicall and
- Economic/Macroeconomic.

The definitions for these are as follows:

Physical/chemical	Covering all physical and chemical aspects of the environment, including finite (non-biological) natural resources, and degradation of the physical environment
Biological / ecological	Covering all biological aspects of the environment, including renewable natural resources, conservation of biodiversity, species interactions pollution of the biosphere
Socioeconomic	Covering all human aspects of the environment, including social issues affecting individuals and communities; together with cultural aspects, including conservation of heritage, and human development
Macroeconomic	Covering macroeconomic consequences of environmental change, both temporary and permanent within the context of the project activities

Sensitive parameters in all the study disciplines that describe the impacts for the current situation (Section 4) during construction for the refinery upgrade and after the Refinery Upgrade (this section) will be assessed for their overall impact using the rapid impact assessment matrix (RIAM) method (Jensen, 1998). The RIAM method provides an overall assessment where there are multi-disciplinary factors since the method allows data from different disciplines to be analysed against common important criteria within a common matrix, thereby providing a clear assessment of the major impacts. Such an assessment can be done for each project alternative and in the present case will be done for the “do nothing” case and for the preferred alternative (during construction and operation).

The RIAM is based on two groups of assessment criteria and the means by which semi-quantitative values for each of these criteria can be assigned for the impacts in the four environmental components and then consolidated to give an overall assessment. The impacts of project activities in the environmental components are assessed against the two groups of criteria, and for each component, a score (using the defined criteria) is determined, which provides a measure of the impact expected from the component.

The assessment criteria fall into two groups:

Criteria that are of importance to the condition, and which can individually change the score obtained.

Criteria that are of value to the situation, but individually should not be capable of changing the score obtained.

The value ascribed to each of these groups of criteria is determined by the use of a series of simple formulae. These formulae allow the scores for the individual components to be determined on a defined basis.

The scoring system requires simple multiplication of the scores given to each of the criteria in group (A). The use of multiplier for group (A) ensures that the weight of each score is expressed (since summation of scores could provide identical results for different conditions).

Scores for the value criteria group (B) are added together to provide a single sum. This ensures that the individual value scores cannot influence the overall score, but that the collective importance of all values in group (B) is fully taken into account.

The sum of the group (B) scores is then multiplied by the result of the group (A) scores to provide a final assessment score (ES) for the condition.

The process can be expressed as follows.

$$(a1) \times (a2) = aT$$

$$(b1) + (b2) + (b3) = bT$$

$$(aT) \times (bT) = ES$$

Where

(a1) and (a2) are the individual criteria scores for group (A)

(b1) to (b3) are the individual criteria scores for group (B)

aT is the result of multiplication of all (A) scores

bT is the result of summation of all (B) scores

ES is the assessment score for the condition.

Positive and negative impacts are depicted by using scales that go from negative to positive values through zero for the group (A) criteria. Zero is the ‘no-change’ or ‘no-importance’ value. The use of zero in group (A) criteria allows a single criterion to isolate conditions which show no change or are unimportant to the analysis.

Zero is avoided in the group (B) criteria. If all group (B) criteria score zero, the final result of the ES will also be zero. This condition may occur even where the group (A) criteria show a condition of importance that should be recognised. To avoid this, scales for group (B) criteria use '1' as the 'no-change/no-importance' score.

Assessment criteria

The criteria, together with their appropriate judgement scores are as follows.

Group (A) criteria

Spatial Importance of condition (A1)

A measure of the importance of the condition, which is assessed against the spatial boundaries or human interests it will affect.

The scales are defined as follows:

4 = important to national/international interests

3 = important to regional/national interests

2 = important to areas immediately outside the local condition (aspect-specific study areas)

1 = important only to the local condition (Petrojam plant site)

0 = no importance.

Magnitude of change/effect (A2)

Magnitude is defined as a measure of the scale of benefit/dis-benefit of an impact or a condition:

+3 = major positive benefit

+2 = significant improvement in status quo

+1 = improvement in status quo

0 = no change/status quo

-1 = negative change to status quo

-2 = significant negative dis-benefit or change

-3 = major dis-benefit or change.

Group (B) criteria

Permanence (B1)

This defines whether a condition is temporary or permanent, and should be seen only as a measure of the temporal status of the condition.(e.g.: an embankment is a permanent condition even if it may one day be breached or abandoned; whilst a coffer dam is a temporary condition, as it will be removed).

1 = no change/not applicable

2 = temporary

3 = permanent.

<u>Reversibility (B2)</u>

This defines whether the condition can be changed and is a measure of the control over the effect of the condition. It should not be confused or equated with permanence.

1 = no change/not applicable

2 = reversible

3 = irreversible.

<u>Cumulative (B3)</u>

This is a measure of whether the effect will have a single direct impact or whether there will be a cumulative effect over time, or a synergistic effect with other conditions. The cumulative criterion is a means of judging the sustainability of a condition, and is not to be confused with a permanent/irreversible situation.

1 = no change/not applicable

2 = non-cumulative/single

3 = cumulative/synergistic

It is possible to change the cumulative component to one of synergism, if the condition warrants consideration of additive effects.

Overall Assessment

The various ES values are grouped into ranges and assigned alphabetic or numeric codes (see Table 6-1) so they may be more easily compared.

The assessments that follow are made first for the period during construction and after the upgrade. The bases for assessment of the existing situation were provided in Section 4.

Tabulations of the ES scores for each of the four environmental components (Physical/Chemical, Biological/ecological, Socioeconomic/cultural and Macroeconomic) are provided in the following four sections.

Table 6-1 Range Value Codes for the Environmental Score (ES)

Environmental Score (ES)	Range value (RV) (Alphabetic)	Range value (RV) (Numeric)	Description of Range
72 to 108	E	5	Major positive change/impact
36 to 71	D	4	Significant positive change/impact
19 to 35	C	3	Moderate positive change/impact
10 to 18	B	2	Positive change/impact
1 to 9	A	1	Slight positive change/impact
0	N	0	No change/status quo/not applicable
-1 to -9	-A	-1	Slight negative change/impact
-10 to -18	-B	-2	Negative change/impact
-19 to -35	-C	-3	Moderate negative change/impact
-36 to -71	-D	-4	Significant negative change/impact
-72 to -108	-E	-5	Major negative change/impact

6.2 IMPACTS DURING CONSTRUCTION

6.2.1 Physical and Chemical Components

6.2.1.1 Hydrology (Surface and Groundwater) Impacts During Construction

Site preparation, demolition and construction activities have the potential to affect surface water runoff and hence the quality and quantity of surface and groundwater. Table 6-2 shows the evaluation of the potential environmental effects resulting from the interaction between construction activities and surface and groundwater.

The site is fully developed and there will be minimal if any clearing of land for construction. The site preparation for foundation and other excavation activities may mobilise surface contaminants and sediment. Management of excavation and demolition piles will be necessary to mitigate the mobilisation and entrainment of suspended particles in run off during precipitation events.

Wash-water from concrete operations normally has a high pH and, if allowed to spill to ground, could affect ground and surface water chemistry. This aspect is evaluated under water chemistry.

Site management will be critical in mitigating the potential for impacts due to these activities.

Flooding

Construction activities will not affect the potential for flooding.

Table 6-2 Potential Project Interactions with Surface and Groundwater

Project Activities and Physical Works	Potential Environmental Effects Change in Groundwater/Surface water	
	Quality	Quantity
Demolition and Construction		
Demolition (tanks & pipelines) and Site Clearing	x	
Site water management	x	X
Marine Vessel Accidents	x	
Operation		
Water Management (process and storm-water)	x	X
Site Waste Management	x	
Maintenance/ Repairs (tanks, pipelines, etc)	x	
Accidents, Malfunctions and Unplanned Events		
Marine Vessel Accidents	x	
Hazardous Materials Spills (fuels, oils etc)	x	

Groundwater Contamination (Previous Spills and Leaks)

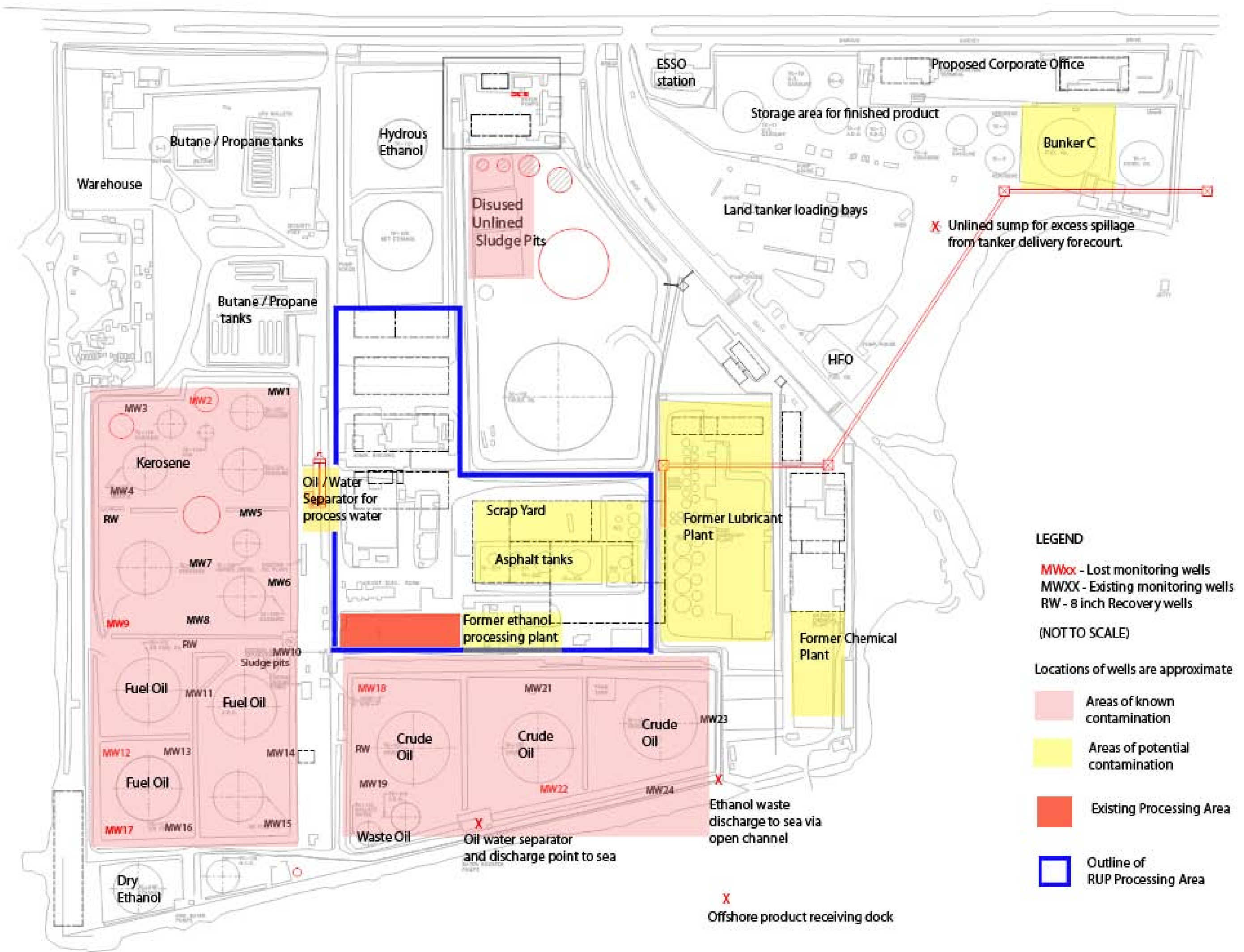
Construction activities (i.e., excavation) could unearth soil that is contaminated by previous leaks from storage tanks. Four new tanks will be constructed – three of which will be in the tank farm to the south-west of the property and the fourth to the northern section of the property (north of the existing large crude oil tank (TK118) and east of the large ethanol tank (TK100). The construction of these tanks is not expected to alter or disturb the contaminated soil below the tanks farm to the south-west of the property.

The RUP processing area includes areas designated as potentially contaminated (see Figure 6-1) and hence excavation in the RUP processing area could unearth soils contaminated with petroleum products and their derivatives (compounds formed when the original petroleum products decompose). The volume of soil to be excavated and the degree of contamination of the sub-soils are unknown and consequently the nature and extent of exposures and impacts are uncertain. The potential impacts include ecological, occupational and human health. Ecological impacts could arise due to the interaction of contaminated excavated soils with rainfall that could mobilise contaminant species causing transfer to surface and ground water. Worker exposure could occur through inhalation of vapours or wind entrained particles released from exposed contaminated soil or by direct contact (skin exposure). The transport of dust and vapours off site could lead to human exposure and adverse health impacts. In view of the uncertainty about the extent of contamination in the areas likely to be excavated and because of potential impacts it is recommended to fully investigate the extent of contamination in the areas where there will be excavation. In the event that these areas show contamination there will be need for mitigation measures (see Section 7).

Drainage Assessment

The construction will not change the overall surface characteristics of the site and the predicted runoff estimates (see Table 4-6) will not be affected.

Figure 6-1 Locations of Known and Potential Hydrocarbon Contamination to Soil and Water and the Existing and RUP Processing Areas



Water Demand

On-site wells will be constructed in order to supply 95 litres/s (1500 gpm) of process water. Removal of groundwater may result in a lowering of the water table, thereby decreasing the amount of groundwater available to other users. However, the WRA has examined the situation and it is their determination that the well will not adversely affect other users (Pers. Commun., 2008).

Storm Surge

The storm surge estimates presented in Section 4.1.3 will not be affected by the construction activities.

6.2.1.2 Water Quality During Construction

Trade effluent quality and quantity will not be affected by the construction activities. Stormwater runoff from the site however could be affected since excavation and other construction activities could lead to increased sediment in run off. The impacts are expected to be minimal since construction activities will take place over ~10 months and demolition over about 4 months.

However, there will be ongoing water quality monitoring during the construction and demolition phases.

6.2.1.3 Air Quality and Occupational Impacts During Construction

During construction there is the potential for the generation of dust from site preparation and construction activities such as excavation, sand blasting and earth moving. Dust generated from these activities are typically larger diameter particles (than for example the finer particles that are generated in combustion sources). The larger particles will not disperse as far from the site. Control measures can be very effective in mitigating dust emissions and these and any necessary ambient monitoring during construction are addressed in 7.1.1.

The dust and noise generated during construction will be of importance to workers on the site and hence the potential concern is occupational exposure as opposed to ambient exposure off-site. Control and protective measures to mitigate and where necessary monitor occupational exposure are described in 7.1.1.

Ongoing refinery operations will not be affected by the construction (i.e., air emissions and occupational exposures will remain the same as in the existing case (addressed in Section 4).

6.2.1.4 Vibration During Construction

Vibration in buildings can arise from internal or external sources. The internal sources originate from machines (elevators, fans, pumps, drop hammers, trolleys, punching presses) and from the activities of people (walking, jumping, dancing, running). External sources arise from road and rail traffic, construction activities (pile driving, blasting, excavation and compacting of soil), sonic booms, strong winds, and earthquakes. Most vibrations are generated inside buildings. The resulting vibrations in buildings may cause impaired function of instruments and rare but possible structural damage. The primary concern is that the vibration can be intrusive and annoying to building occupants.

Vibration consists of oscillatory waves (described in terms of their frequencies and amplitudes) that move from the source through the ground to adjacent buildings. Construction vibration has a range or “spectrum” of many frequencies (typically 1Hz to 200 Hz) and are generally classified as broadband or random vibrations. High frequency vibrations are reduced much more rapidly with increasing distance from the source than low frequencies, so that low frequencies tend to dominate the spectrum at large distances from the source.

Most vibration problems can be described in terms of the source, the transmission path, and the receiver. The receivers in this current context will be the adjacent buildings. The nature of the soil between the source and the receiver has a strong influence on the intensity of the vibrations received. Soft soils result in larger amplitude vibrations than hard or rock-like materials but soft soils attenuate the vibrations somewhat more rapidly with distance.

Typical vibration levels do not have the potential for causing structural damage. Some construction activities, such as pile driving and blasting, can produce vibration levels that may have the potential to damage some vibration sensitive structures if performed within 1 to 30 m (50 to 100 ft) of the structure. The potential vibration impacts during construction are from pile driving, excavation and compacting of soil. Most building structures have a low natural frequency. Structural vibration is greatly increased when the applied vibration frequency falls within the bounds of the buildings natural frequency. This phenomenon is known as resonance and can lead to structural damage in the building.

A measure of the extent of vibration from sources such as blasting or pile driving is the peak particle velocity (PPV) which is the maximum instantaneous positive or negative peak motion of a vibrating surface. The vibration measured as the PPV caused by various types of construction activities will vary depending on the soil conditions. Typical vibration levels at 25 ft for various pieces of construction equipment measured under a wide range of soil conditions are summarised in Table 6-3. The table includes estimates at ~100 m (300 ft) from the source.

Vibration Criteria and Guidelines

Criteria and guidelines for acceptable vibration limits have been derived from experiments, practical experience, and judgement and undergo continual study and development and are periodically changed to incorporate new information. Vibration criteria for occupants have been published by the International Standards Organization (ISO) (ISO, 1973) and have been adopted in the United States (ANSI, 1983) and the United Kingdom (BS, 1984). The U.S. Department of Transportation (U.S. DOT) has guidelines for vibration levels from construction related to their activities, and recommends that the maximum peak-particle-velocity levels remain below 0.05 inches per second at the nearest structures. The estimates in Table 6-3 indicate that at 100 m from sources the vibration levels would be below the criterion.

Table 6-4 summarizes the levels of vibration and the usual effect on people and buildings. Annoyance from vibration often occurs when vibration levels exceed the thresholds of human perception. These perception thresholds are an order of magnitude below the damage threshold for normal buildings and are well below vibration levels at which damage might be expected to occur. Vibration levels above 0.5 inches/sec have the potential to cause architectural damage to normal dwellings. Vibration levels as low as 0.017 to 0.035 PPV (at the receptor location) may often be felt by humans and can be unsettling or annoying, but are well below levels that would result in physical damage. Some construction activities, such as pile driving and blasting, can produce vibration level that may have the potential to damage some vibration sensitive structures if performed within 50 to 100 feet of the structure. The frequencies of the vibrations from construction activities tend to be in the mid- to upper-frequency range which have a lower potential for structural damage than earthquakes, which produce vibration at very low frequencies and have a high potential for structural damage. The options for mitigating vibration during construction and recommendations for mitigation are discussed in Section 7.

6.2.1.5 Emergency Response Plans During Construction

The refinery will continue to operate the existing processing units during the upgrade and no changes in the emergency response plans with respect to processing will be needed. The construction activities are governed by standard safety procedures. All staff engaged in construction activities will be required to undergo Petrojam's Health and Safety orientation and training. The training/orientation will include familiarisation with emergency response plans.

Table 6-3 Vibration Source Levels for Construction Equipment*

Equipment	PPV at 25 ft (in/sec)	Approximate Lv† at 25 ft	PPV at 300 ft (in/sec)	Approx. Lv† at 100 ft
Pile Driver (impact) upper range	1.518	112	0.037	80
Pile Driver (impact) typical	0.644	104	0.015	72
Pile Driver (sonic) upper range	0.734	105	0.018	73
Pile Driver (sonic) typical	0.17	93	0.004	61
Clam shovel drop (slurry wall)	0.202	94	0.005	62
Hydromill (slurry wall) in soil	0.008	66	0.000	34
Hydromill (slurry wall) in rock	0.017	75	0.000	43
Vibratory Roller	0.21	94	0.005	62
Hoe Ram	0.089	87	0.002	55
Large bulldozer	0.089	87	0.002	55
Caisson drilling	0.089	87	0.002	55
Loaded trucks	0.076	86	0.002	54
Jackhammer	0.035	79	0.001	47
Small bulldozer	0.003	58	0.000	26

*From Hanson,C.E., Towers, D.A. and Meister, L.D. (2006). Transit Noise and Vibration Impact Assessment. Report prepared for the Federal Transit Administration, May 2006.
† RMC velocity in decibels (VdB re 1 µinch/sec).

Table 6-4 General Effects of Construction Vibration

Peak Particle Velocity (in/sec)	Effects on Humans	Effects on Buildings
<0.005	Imperceptible	No effect on buildings
0.005 to 0.015	Barely perceptible	No effect on buildings
.02 to 0.05	Level at which continuous vibrations begin to annoy in buildings	No effect on buildings
00.1 to 0.5	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
0.5 to 1.0	Vibrations considered bothersome by most people, however tolerable if short-term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
1.0 to 2.0	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range
>3.0	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

6.2.2 Biological Impacts During Construction

6.2.2.1 Terrestrial Impacts During Construction

Potential terrestrial impacts during construction are negligible since the site is a well developed industrial site and no changes in the habitat are likely. Activities such as improper management and/or storage/removal of maintenance debris could create breeding sites for pests and also lead to blockage of storm-water drainage channels.

6.2.2.2 Marine Impacts During Construction

Potential marine impacts due to construction activities can arise from runoff water that contains construction related sediment and hydrocarbon contaminants. The construction related discharges are not likely to be significant once mitigative housekeeping measures to reduce runoff from construction affected by construction activities are put in place.

It is anticipated that there may be periodic dredging activities to maintain the docking capability of ships offloading or loading materials at the loading dock. Such dredging will require licences that will address dredging impacts and therefore is outside the scope of this EIA.

6.2.3 Socioeconomic Impacts During Construction

Land Use

Land use by the proposed project will be limited to the existing Petrojam property and hence there will be neither land use impacts nor will there be any direct impacts on land use in surrounding areas. The site is located within an industrial area as defined by the Kingston Development Order. The use of the site is therefore in compliance with the Order.

Community Development

The proposed project will have no direct impact on community development during construction as the project is confined to the Petrojam property which is separated from the communities by the dual carriageway Marcus Garvey Drive. The Greenwich Town Fishing Beach which is adjacent to the Petrojam site will not be impacted as the construction will be concentrated at the central and eastern end of the Petrojam site. These activities are at least 0.5 km from the Fishing Beach.

There should be indirect impacts through employment opportunities for persons from communities. Persons may be motivated to acquire the necessary skills required for available positions, hence increasing the skills set of the area. Temporarily, unemployment may be reduced; and there would be more residual income to spend in neighbourhood commercial institutions.

Public Perception

The public perception (based on survey and other data described in Section 4.3.3.1) was generally very positive about the construction phase of the project although there were concerns about specific aspects (air pollution, hazardous waste) and in some cases indifference (proposed project would not affect them). The weighting assigned in the RIAM assessment assumed the project is permanent, irreversible and will have synergistic effects.

Employment and Income

Employment and income would be impacted positively by the proposed development. The positive impact is represented by the creation of jobs during construction of the development. Petrojam has estimated that approximately 1,200 to 2,000 skilled jobs will be required during the construction phase of the project. The required skills include welders, mechanics, pipe-fitters and general construction workers. However, the socioeconomic and perception survey results indicated that the communities surrounding the proposed project site have low level of skill sets which may reduce benefits to them.

The implementation of training programs especially within the communities adjacent to the refinery between now and when construction starts will be an important initiative to help secure employment opportunities. The training programs should encompass those directly related to Petrojam's needs factor as well as those needed for the spin off industries and the in multiplier industries and services.

Traffic

Traffic impacts will be temporary. There will be an increase in vehicular traffic for the movement of construction materials and equipment on and off site and for construction workers. Due to the nature of the project, there may be the movement of large and overweight equipment. Information from Petrojam indicated that this would most likely be equipment from the wharf at Kingston. Such equipment would be transported at night with the aid of the police and the JPS.

The study site is located along a four-lane dual carriageway which has been recently upgraded. This will facilitate the movement of large equipment and the increased capacity (over 30,000 vehicles per day) will easily accommodate any increase in traffic during construction. However, where feasible the larger pieces of equipment will be moved by barge from the port to the Petrojam loading dock.

The impacts on traffic will be minimal since the main roadways can easily accommodate the small increase in vehicular traffic (for construction workers) during construction.

Heritage Sites and Community Activities

Since there are no heritage sites located within 0.5 km of the Petrojam site there can be no impact on the heritage sites. The regular activities of the surrounding communities will not be affected by the construction activities for the upgrade.

6.2.4 Macroeconomic Impacts During Construction

The macroeconomic impacts during construction will be limited to the increases in imports of machinery and equipment used in the upgrade and in the supply of local construction materials (e.g., cement, gravel). Since there will be no changes in the operation and production at the refinery there will be no changes in the foreign exchange or imports that relate to petroleum products.

The total project cost is estimated at US $758 million of which it is anticipated that 25 -30% will be financed locally. The construction will require 1200 to 2000 skilled workers. The wages earned during construction will generate the need for goods and services in the local and wider community (multiplier effect). The technical knowledge transfer for the design and construction will build local capacity that will be useful for other projects and industries.

6.3 IMPACTS AFTER UPGRADE

6.3.1 Physical and Chemical Impacts After the Upgrade

6.3.1.1 Hydrology (Surface and Groundwater) Impacts After the upgrade

Activities associated with the operation of the refinery after the upgrade that has the potential to affect ground and surface water quality and/or quantity include:

- Groundwater management;
- Storm Water and Wastewater management; and
- Maintenance / repairs of tanks and pipelines.
- Accidents, malfunctions and unplanned events

The potential interactions with surface and groundwater are summarised in Table 6-5.

Table 6-5 Potential Project Interactions with Surface and Groundwater

Project Activities and Physical Works	Potential Environmental Effects Change in Groundwater/Surface water	
	Quality	Quantity
Water Management (process and storm-water)	x	x
Site Waste Management	x	
Maintenance/ Repairs (tanks, pipelines, etc)	x	
Accidents, Malfunctions and Unplanned Events		
Marine Vessel Accidents	x	
Hazardous Materials Spills (fuels, oils etc)	x	

Groundwater Management

The abstraction wells will be the same as that used in the construction phase. As previously noted (Section 4.1.2.4.1) the wells will be sized to manage the abstraction of water from the aquifer. This will ensure that should there be any adverse effects at higher pump rates then the production rate can be adjusted to ensure that the drawdown effect is minimal. The wells will also be located down gradient of other non-Petrojam wells located to the north. As a result, adverse environmental effects on those wells are not anticipated.

Groundwater Quality and Contamination

Current groundwater quality at the site is impacted by the location of the site in the Liguanea aquifer and from past and current refinery activities (see Section 4.1.3). The site is subject to saline intrusion as is typical of wells in the lower reaches of the Liguanea Plain. As is the case with other wells in the vicinity, water from Petrojam's on-site well is treated by reverse osmosis to remove the high ionic burden in the groundwater.

Non-production wells (i.e., for monitoring on-site groundwater contamination by petroleum hydrocarbons) reflect impacts from previous leakage from storage tanks. Petrojam has implemented groundwater remediation activities to correct these past impacts. These remediation activities will continue.

Storm Water and Wastewater Management

The storm water and process related wastewater streams will be designed as separate systems each of which will be treated prior to discharge.

Process related wastewater arise from floor drains, process areas, chemical storage areas and equipment drains will be collected and routed to the wastewater treatment plant. The system will be designed to collect, separate and treat the oil and process stream contaminated waste streams prior to discharge to the sea.

The upgrade will result in a negligible increase in the hard surface area onsite and there will be no increase in runoff of rain/storm water. The drains from the new processing area will be designed to handle the runoff from a 1 in 10 year storm event. Wastewater streams from the processing area will be treated in a new wastewater treatment plant (WWTP). The WWTP will provide secondary treatment that will meet NEPA's trade effluent standards (see Section 6.3.1.2 that follows).

Potential Impacts of Accidents, Malfunctions and Unplanned Events on Ground and Surface Water

The evaluation of potential impacts on ground and surface water due to incidents such as accidents, malfunctions and unplanned events is summarized below.

In view of the historical leaks from tanks in addition to remediation measures Petrojam implemented enhanced housekeeping activities and an environmental protection plan (EPP) that is designed to reduce such occurrences and to reduce if not eliminate leaks in tank farms.

The EPP includes a detailed marine spill containment plan that includes drills at least annually to ensure the response is timely and coordinated. The upgrade will result in increase marine traffic both for importing crude and exporting products. In view of the increased marine activity it will be recommended that the EPP be reviewed and upgraded as needed.

In view of the existing EPP and ongoing remediation activities the potential impacts from spills, accidents and unplanned events are considered not significant as a result of the upgrade.

Drainage Assessment

The upgrade will not change the overall surface characteristics of the site and the predicted runoff estimates (see Table 4-6) will not be affected.

Storm Surge

The storm surge estimates presented in Section 4.1.3 will not be affected by the upgrade.

6.3.1.2 Water Quality

One of the key features of the upgrade is the construction of a new wastewater treatment plant. The existing API separator frequently failed to meet the proposed trade effluent standards. The wastewater treatment plant will be integrated with the Oily Water sewerage system for the new processing areas.

The Oily Water system for the upgraded refinery is an underground system designed to collect oil/oily water from process equipment drains and run-off from the slab-on-grade in the new process units. In addition to accepting process oily water, the sewerage system is designed to collect storm water from the processing area (based on a design capacity for a 1 in 10 year storm event).

A new API separator will be installed to receive Oily Water from the new process area and the existing API separator will be upgraded. The new API separator will be designed to hold in place (with no overflow) all oily water generated from the new process area during normal operation as well as normal oily water from the existing plant received in the existing API separator.

The new API separator will be provided with a floating skimmer (drum, rope or disc type) which will continue to operate irrespective of the level in the API separator. Oil will be skimmed off into an adjacent oily slop sump from where it will be pumped to the Refinery Slop tank. There will be no communication between the API separator and the Oily slop sump other than through the skimmer.

The new API separator has been sized so that, when the maximum oily water of 4000 gpm is received during a 1 in 10 year storm, hold-up is sufficient to remove oil droplets > 150 microns which is its primary function. However, when the influent water is greater than the capacity of the sump pumps, the water will rise above the high level mark and eventually flow over the weir to the storm water sewer. Under these circumstances, the effluent from the API separator, will not meet World Bank standards but this is expected to occur only for 15 minutes during a 1 in 10 year storm or during a plant fire when oil separation also would be affected.

Wastewater Treatment Plant

The wastewater treatment plant will provide secondary treatment of wastewater from the API separators. A schematic of the effluent treatment units is shown in Figure 6-2 and a schematic of the wastewater treatment plant (WWTP) is shown in Figure 6-3. The WWTP will employ a parallel design with equalisation tanks (EQ TK) followed by sequencing batch reactors (SBR), dissolved air flotation (DAF) which will then be treated by a single aerobic digester and a sludge thickener. The parallel design allows one tank to be in the settle/decant mode while the other is aerating and filling. The system is designed to meet NEPA trade effluent standards (see Table 4-11). Sludge will be disposed of at the NSWMA landfill.

Figure 6-2 Schematic of Effluent Treatment Units in the Upgraded Refinery

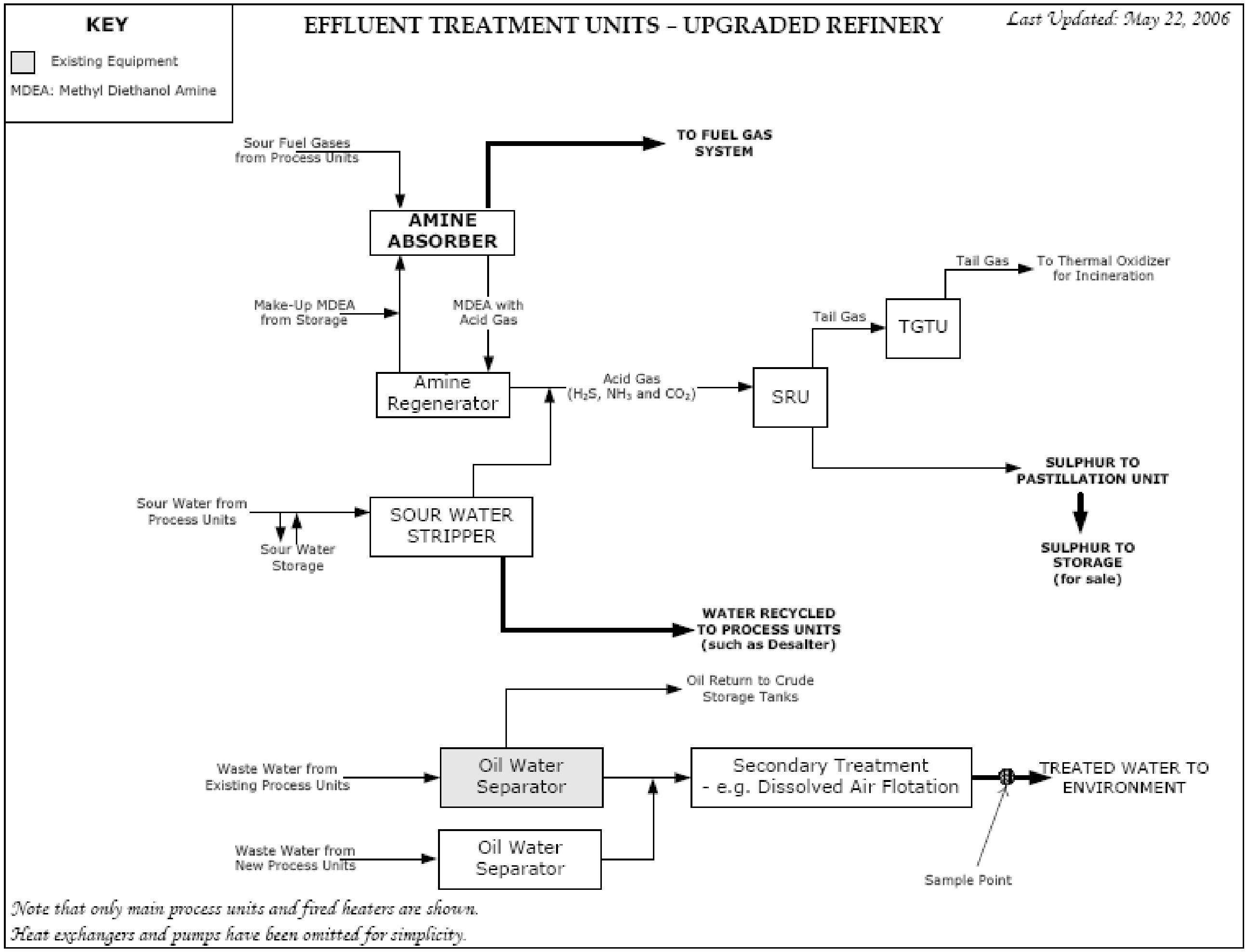
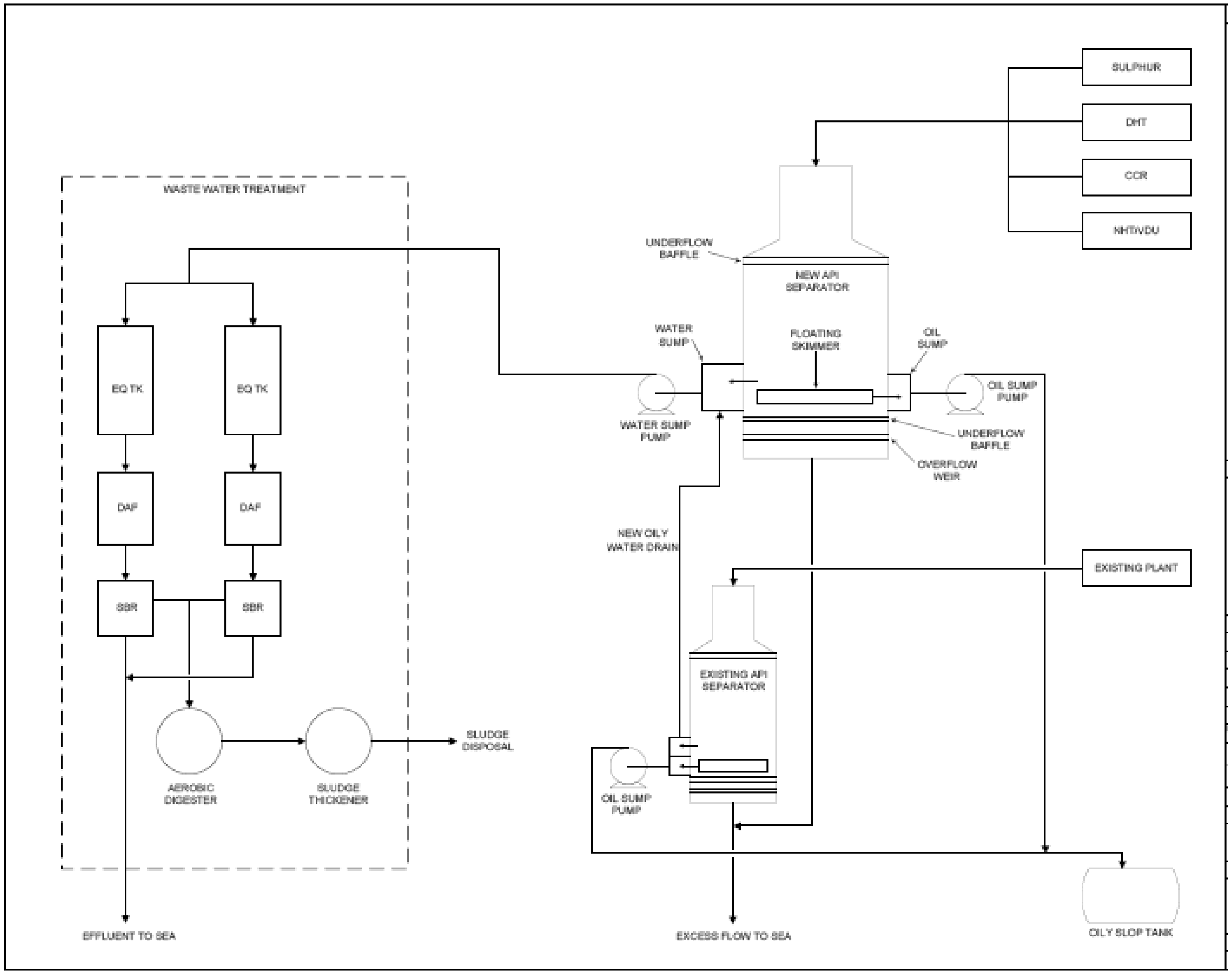


Figure 6-3 Process Flow for the Oily Water and Wastewater Treatment Plant



6.3.1.3 Air Pollution – Potential Impacts after the Upgrade

Air Quality impacts after the upgrade were assessed by looking at the air pollution emissions from the Petrojam refinery alone and also in combination with those from other point sources in the Kingston airshed. The potential incremental air quality impacts were determined by modelling the dispersion of air pollutants from the existing sources and from sources after the upgrade. The sources other than those at Petrojam were the same in both sets of model runs.

6.3.1.3.1 Air Pollution Sources

Air pollutants are emitted from the Petrojam refinery as the result of (a) combustion of fuel and the flaring of unwanted refinery gases (b) evaporative losses from storage tanks and from the loading of products & unloading of raw materials and (c) fugitive emissions due to leakage from equipment (e.g., valves and flanges). Since the upgrade will include the production of pet coke, there is the potential for increased particulate emissions due to the production and handling of coke. Detailed descriptions of the methods used to estimate particulate emissions from the coking operations process are provided since they represent a potential new source of particulate emissions after the upgrade.

6.3.1.3.2 Air Pollution Due To Fuel Combustion and Treatment of Unwanted Refinery Gases

Fuel is burnt in boilers to produce steam and in heaters to heat various refinery streams. Unwanted refinery gases are flared (burnt). Gaseous emissions from the fuel combustion and flaring include sulphur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (defined as total suspended particulate matter or TSP), carbon dioxide and carbon monoxide. Fuel combustion emissions also include smaller amounts of volatile organic compounds (VOCs) and other organic compounds that result from incomplete combustion of fuel.

One of the key features of the upgrade is the treatment of sour gases (hydrogen sulphide and other organic sulphur compounds) that will be generated in the new processes. Since the refinery will be able to process crudes with higher sulphur content and because these sulphur compounds must be removed to produce low sulphur fuels (diesel and gasoline) the sour gases generated in the process units must be removed. This is achieved by the system shown in Figure 6-2. Sour gases are treated in the amine absorber where the solvent methyldiethanolamine (MDEA) is used to absorb sulphur containing acid gases. The MDEA solution is treated to recover the solvent and the acid gases (along with similar gases produced from stripping sour water) are sent to a sulphur recover unit (SRU in Figure 6-2) where elemental sulphur is produced. The tail gases from the SRU still contain small amounts of sulphur gases which are removed in a tail gas treatment unit and thermal oxidiser. Because of the potential for upsets, the tail gas unit will be fitted with a continuous emission monitor (CEM) to monitor the effectiveness of the tail gas unit. An emergency flaring system is included to handle any upsets in the sulphur treatment units.

The amounts of SO_2 emitted are calculated from the sulphur content of each type of fuel and the amount of fuel burned. All other emissions (NOx, TSP, VOCs, H_2S) are estimated from the amounts of fuel used and from emission factors that have been reviewed and accepted by U.S.

EPA. All short term emission rates were based on maximum output from each source so that the worst case situation is used in the dispersion model. Long term (annual) emissions were based on the short term emissions and the expected number of hours of operation for a typical year. This is expressed as a 90% capacity factor – i.e., the refinery is expected to operate for 90% of the hours in the year.

It should be noted that motor vehicles which are one of the largest sources of urban air pollutant emissions of CO, NOx and TSP (and volatile organic compounds) were accounted for by assuming background concentrations for NOx and TSP and therefore were not included in the model predictions.

Except for the vacuum furnace (with source ID F201) and two boilers (New Cleaver Brooks and the Nebraska) all of the other existing stacks and the flare will be replaced after the upgrade. The upgrade will result in 9 new stacks and a new flare. Details of the sources in the airshed after the upgrade are presented in Table 6-6 and Table 6-7.

There will also be changes in the evaporative emissions due to the increased amount of crude oil imported and from the export of new products, namely, vacuum gas oil (VGO) and heavy coker gas oil (HCGO). The evaporative losses due to the storage of other products (gasoline, diesel, heavy fuel oil, and ethanol) will be similar before and after the upgrade since the current importation of these products will be offset by the increased production.

6.3.1.3.3 Evaporative Emissions from Storage Tanks and Loading of Products

Tanks used to store liquid petroleum fuel raw materials and products are sources of hydrocarbon vapour (VOCs) emissions released to the atmosphere. The type of material stored, tank characteristics, net throughput through the tanks and meteorological conditions are factors that influence the amounts of VOCs released. VOC emissions are estimated using software published by the USEPA and are based on US EPA emission factors. The US EPA Tanks software together with meteorological conditions for the Norman Manley International Airport and tanks characteristics and throughput data provided by Petrojam were used to estimate speciated VOC emissions before and after (Table 6-8) the upgrade. Emission rates for individual VOCs (i.e., speciated emissions) before and after the upgrade are given in Table 6-9.

Emissions from loading operations are shown in Table 6-10. The available emission factors and the assumed loading conditions are included in the table. Since there would be no change in the quantity of products loaded the emission rates are the same before and after the upgrade. Note that there is no distinction in emission factors for various types of gasoline (i.e., emission factors for regular gasoline oxygenated with MTBE and E10 are the same).

In Tables 6-8 to 6-10 the emissions after the upgrade (tanks designated as U if their content changed or is a new tank) also took into account the possibility the all gasoline after the upgrade would be E10 (tanks designated as UE).

Table 6-6: Characteristics of Kingston Airshed Point Sources after Petrojam Upgrade

Description	Source ID	Zone 18 UTM E (m)	Zone 18 UTM N (m)	Stack Height (m)	Temp (K)	Exit Vel. (m/s)	Stack Dia. (m)
Petrojam Vacuum Furnace	F201	307507.1	1988266	20.5	683	3.71	0.610
DG Eastmost stack	DG1	305922.7	1991542	18.0	533	12.0	0.722
DG Westmost	DG3	305904.7	1991557	18.0	523	11.9	0.600
DG Centre stack	DG2	305913.7	1991549	18.0	523	11.9	0.600
JPPC Engine 1	JPPC1	314376	1987692	65.0	572	45.9	1.80
JPPC Engine 2	JPPC2	314380	1987692	65.0	572	45.9	1.80
Dry Kiln stack	CCCLD	316680	1987152	44.0	433	12.8	2.60
Wet Kiln stack	CCCLW	316542.6	1987325	44.0	433	9.40	2.60
JPS Rockfort	JPSROCK	314500	1987543	38.8	645	26.2	1.76
JPS Rockfort	JPSROCK2	314500	1987554	38.8	666	30.8	1.76
JPS Hunts Bay B6	JPSHBB6	308271	1987952	45.7	436	19.4	2.90
JPS Hunts Bay GT10	JPSHGT10	308364	1987948	11.5	689	15.8	4.20
Jamaica Ethanol 1	JAETH1	315203	1987788	6.10	359	11.1	0.762
Caribbean Products	CP1	305581.4	1991871	14.6	368	7.46	0.560
JPS Hunts Bay A5	JPSHBA5	308569	1988137	12.0	766	8.30	4.12
Clinker cooler 3	CCCLR3	316629	1987263	24.4	443	20.4	2.17
Clinker cooler No 4	CCLR4	316637	1987289	24.4	478	20.0	2.17
Petrojam Sulphur C	45ME01	307633.3	1988416	35.0	547	6.77	1.01
Petrojam DHT	22F01	307590.8	1988366	35.0	645	6.40	1.16
Petrojam CCR	31F04	307563.2	1988336	35.0	539	7.19	1.52
Petrojam NHT	21F01	307520.1	1988314	35.0	615	2.99	0.762
Petrojam DCU	13F01	307657.7	1988157	35.0	422	6.55	1.68
Petrojam VDU-oil	11F01	307538.1	1988298	60.0	628	6.58	2.44
Petrojam CDU-oil	01F05	307504.7	1988283	60.0	589	7.92	2.10
Petrojam H2 Plant	25F01	307544.6	1988259	35.0	478	5.09	2.44
Petrojam Utility Boiler	BNEW/650	307658.4	1988425	60.0	616	4.72	2.53
Petrojam DCU 2	23F01	307597.5	1988282	33.5	561	1.31	0.762
Petrojam Flare New	FLAREN	307304.1	1988198	65.2	1273	20.0	0.034
Petrojam Boiler B2 125# New Cleaver Brooks	B125#2	307524.1	1988223	18.3	603	74.6	0.406
Petrojam Boiler 125 # B3 Nebraska	B125#3	307531.7	1988240	17.4	603	6.41	2.06

Table 6-7: Kingston Airshed Point Source Emission Rates After Petrojam Upgrade

After Upgrade		Maximum Hourly Emission Rates					Annual Emission Rates				
		SO_2 (g/s)	NOx (g/s)	PM (g/s)	CO (g/s)	VOC (g/s)	SO_2 (tonne/y)	NOx (tonne/y)	PM (tonne/y)	CO (tonne/y)	VOC (tonne/y)
Petrojam Vacuum furnace	F201	2.52	0.146	0.00314	0.04	0.0114	71.5	4.15	0.09	1.04	0.32
DG Eastmost stack	DG1	9.81	0.979	0.610	0.104	0.153	278	27.8	17.3	2.96	4.33
DG Westmost	DG3	6.85	0.683	0.547	0.0727	0.106	194	19.4	15.5	2.06	3.02
DG Centre stack	DG2	6.85	0.683	0.547	0.0727	0.106	194	19.4	15.5	2.06	3.02
JPPC Engine 1	JPPC1	36.6	143	10.0	30.71	11.65	1039	4050	284	872	331
JPPC Engine 2	JPPC2	36.6	143	10.0	30.71	11.65	1039	4050	284	872	331
Dry Kiln stack	CCCLD	4.38	28.0	2.11	7.94	0.00	124	796	59.9	225	0
Wet Kiln stack	CCCLW	42.30	38.1	2.37	0.060	0.00	1201	1082	67.3	1.70	0.00
JPS Rockfort	JPSROCK	101	55.70	2.80	133	6.99	2864	1581	79.5	3769	198
JPS Rockfort	JPSROCK2	117	47.10	2.90	133	6.99	3329	1337	82.3	3769	198
JPS Hunts Bay B6	JPSHBB6	251	26.10	9.90	226	1.44	7132	741	281	6409	40.8
JPS Hunts Bay GT10	JPSHGT10	18.2	28.3	3.35	1.50	0.00574	781	804	95.1	42.6	0.16
Jamaica Ethanol 1	JAETH1	15.0	1.76	0.720	0.160	0.165	427	50.0	20.4	4.54	4.67
Caribbean Products	CP1	7.85	0.0220	0.51	0.080	0.123	223	0.624	14.6	2.27	3.49
JPS Hunts Bay A5	JPSHBA5	27.5	25.4	2.20	0.900	8.82E-06	517	720	62.4	25.5	0.00
Clinker cooler 3	CCCLR3	0.00	0.00	0.70	0.00	0.00	0.00	0.00	19.9	0.00	0.00
Clinker cooler No 4	CCLR4	0.00	0.00	1.10	0.00	0.00	0.00	0.00	31.2	0.00	0.00
Petrojam Sulphur C	45ME01	1.85	0.00	0.00	0.189	0.00	52.6	0.00	0.00	5.37	0.00
Petrojam DHT	22F01	0.00391	0.636	0.0136	0.159	0.0127	0.111	18.0	0.39	4.51	0.36
Petrojam CCR	31F04	0.00908	1.46	0.0313	0.365	0.0292	0.258	41.5	0.89	10.4	0.83
Petrojam NHT	21F01	0.00088	0.131	0.00281	0.033	0.00263	0.025	3.73	0.08	0.93	0.07
Petrojam DCU	13F01	0.0129	2.05	0.0438	0.511	0.0409	0.365	58.1	1.24	14.5	1.16
Petrojam VDU-oil	11F01	57.6	0.137	3.81	0.612	0.0343	1636	3.89	108	17	0.97
Petrojam CDU-oil	01F05	47.8	0.114	3.16	0.508	0.0284	1358	3.23	89.7	14.4	0.81
Petrojam H2 Plant	25F01	0.0373	2.80	0.060	0.699	0.0559	1.06	79.3	1.70	19.8	1.59

After Upgrade		**Maximum Hourly Emission Rates**						**Annual Emission Rates**				
		SO_2 (g/s)	**NOx (g/s)**	**PM (g/s)**	**CO (g/s)**	**VOC (g/s)**		**SO_2 (tonne/y)**	**NOx (tonne/y)**	**PM (tonne/y)**	**CO (tonne/y)**	**VOC (tonne/y)**
Petrojam Utility Boiler	BNEW/650	71.6	0.170	4.73	0.760	0.0148		2032	4.83	134	21.6	0.42
Petrojam DCU 2	23F01	1.20	0.0566	0.0126	0.014	0.0002		33.9	1.61	0.36	0.40	0.01
Petrojam Flare New	FLAREN	0.315	0.0685	4.90E-04	0.376	0.0132		8.94	1.94	0.01	10.7	0.38
Petrojam Boiler B2 125# NCBB	B125#2	17.1	0.041	1.13	0.181	0.0102		485	1.15	32.0	5.14	0.29
Petrojam Boiler 125#B3 NBRSKA	B125#3	37.6	0.089	2.48	0.399	0.0224		1,067	2.54	70.5	11.3	0.63
Total After Upgrade		919	546	65.8	569	39.6		26,088	15,501	1,869	16,137	1,125
Petrojam After Upgrade		238	7.89	15.5	4.84	0.276		6,746	224	439	137	7.84
Petrojam Existing		117	6.75	6.91	1.29	0.054		3,570	192	212	39	1.57
Increase		120	1.14	8.56	3.56	0.22		3,176	32	227	98	6.3

Table 6-8 Summary of VOC Emission Rates from Tanks Before and After the Upgrade

Tank ID	Type	Service	Losses (lbs)	Losses (kg)
100	Vertical Fixed Roof Tank	Ethyl alcohol	98,992	44,902
101	External Floating Roof Tank	Residual oil no. 6	170	77
102	External Floating Roof Tank	Crude oil (RVP 5)	22,481	10,197
103	External Floating Roof Tank	Crude oil (RVP 5)	22,481	10,197
104	External Floating Roof Tank	Gasoline (RVP 10)	110,081	49,932
105	External Floating Roof Tank	Gasoline (RVP 10)	106,018	48,089
106	Vertical Fixed Roof Tank	Jet kerosene	736	334
107	External Floating Roof Tank	Gasoline (RVP 10)	96,356	43,706
108	Internal Floating Roof Tank	Methyl-tert-butyl ether (MTBE)	6,821	3,094
109	Vertical Fixed Roof Tank	Jet kerosene	6,799	3,084
110	Vertical Fixed Roof Tank	Distillate fuel oil no. 2	10,726	4,865
111	Vertical Fixed Roof Tank	Residual oil no. 6	77	35
112	Vertical Fixed Roof Tank	Residual oil no. 6	130	59
113	Vertical Fixed Roof Tank	Residual oil no. 6	68	31
114	Vertical Fixed Roof Tank	Heavy Virgin Naphtha (modelled as Distillate fuel oil no. 2)	189	86
116	Vertical Fixed Roof Tank	Residual oil no. 6	33	15
118	External Floating Roof Tank	Crude oil (RVP 5)	30,800	13,971
119	External Floating Roof Tank	Gasoline (RVP 10)	85,610	38,832
120	Vertical Fixed Roof Tank	Residual oil no. 6	14	6
121	Internal Floating Roof Tank	Gasoline (RVP 10)	9,734	4,415
125	Vertical Fixed Roof Tank	Sour water	-	-
200	Vertical Fixed Roof Tank	Asphalt	-	-
201	Vertical Fixed Roof Tank	Asphalt	-	-
202	Vertical Fixed Roof Tank	Asphalt	-	-
203	Vertical Fixed Roof Tank	Asphalt	-	-
210	Vertical Fixed Roof Tank	Distillate fuel oil no. 2	1,603	727
400-D1	Vertical Fixed Roof Tank	Ethyl alcohol	1,688	766
400-D2	Vertical Fixed Roof Tank	Ethyl alcohol	460	209
400-M	Vertical Fixed Roof Tank	Ethyl alcohol	3,198	1,451
400-S	Vertical Fixed Roof Tank	Ethyl alcohol	16,646	7,551
LR03	Vertical Fixed Roof Tank	Jet kerosene	938	426
LR04	Internal Floating Roof Tank	Gasoline (RVP 10)	9,322	4,228
LR05	Internal Floating Roof Tank	Gasoline (RVP 10)	12,982	5,889
LR06	Vertical Fixed Roof Tank	Jet kerosene	1,158	525
LR07	Vertical Fixed Roof Tank	Distillate fuel oil no. 2	530	241

Tank ID	Type	Service	Losses (lbs)	Losses (kg)
LR08	Vertical Fixed Roof Tank	Methyl-tert-butyl ether (MTBE)	37,221	16,883
LR09	Vertical Fixed Roof Tank	Distillate fuel oil no. 2	2,314	1,049
LR10	Internal Floating Roof Tank	Gasoline (RVP 10)	13,391	6,074
LR11	External Floating Roof Tank	Gasoline (RVP 10)	107,423	48,726
LR12	Vertical Fixed Roof Tank	Residual oil no. 6	17	8
101U	External Floating Roof Tank	Distillate fuel oil no. 2	548	249
102U	External Floating Roof Tank	Distillate fuel oil no. 2	507	230
103U	External Floating Roof Tank	Crude oil (RVP 5)	22,920	10,396
118U	External Floating Roof Tank	Crude oil (RVP 5)	30,800	13,971
122U	External Floating Roof Tank	Distillate fuel oil no. 2	229	104
123U	Vertical Fixed Roof Tank	Distillate fuel oil no. 2	1,452	658
124U	External Floating Roof Tank	Crude oil (RVP 5)	22,616	10,258
104UE	External Floating Roof Tank	Gasoline (RVP 11)	128,971	58,500
107UE	External Floating Roof Tank	Gasoline (RVP 11)	112,891	51,206
119UE	External Floating Roof Tank	Gasoline (RVP 11)	100,302	45,496
121UE	Internal Floating Roof Tank	Gasoline (RVP 11)	11,363	5,154
LR04UE	Internal Floating Roof Tank	Gasoline (RVP 11)	10,883	4,936
LR05UE	Internal Floating Roof Tank	Gasoline (RVP 11)	15,156	6,875
LR105UE	Internal Floating Roof Tank	Gasoline (RVP 11)	15,771	7,153
LR10UE	Internal Floating Roof Tank	Gasoline (RVP 11)	15,686	7,115
LR11UE	External Floating Roof Tank	Gasoline (RVP 11)	125,859	57,089
	Total Existing			370,687
	Total After Upgrade			372,103
	After Upgrade Ethanol Only			403,267

*Tank IDs ending with “U” are tanks after the upgrade and with “UE” after the upgrade with all gasoline as E10 and no MTBE used

Table 6-9: Speciated Emission Rates from Tanks Before and After Petrojam Upgrade

USERID	CONTENTS	1,2,4-Trimethylbenzene	Benzene	Cyclohexane	Ethanol	Ethylbenzene	Hexane (-n)	Isooctane	Isopropyl benzene	Methyl-tert-butyl ether (MTBE)	Toluene	Unidentified Components	Xylene (-m)
101	Residual oil no. 6												
102	Crude oil (RVP 5)	1	59	70		5	61	0	1		31	4384	15
103	Crude oil (RVP 5)	1	59	70		5	61	0	1		31	4384	15
104	Gasoline (RVP 10)	6	164	22		15	142	0	3	2778	201	19255	63
105	Gasoline (RVP 10)	6	157	21		14	136	0	2	2657	191	18570	59
106	Jet kerosene		1			3	2				9	130	7
107	Gasoline (RVP 10)	5	144	20		13	124	0	2	2431	176	16855	55
108	Methyl-tert-butyl ether (MTBE)									1403			
109	Jet kerosene		8			30	16				85	1200	61
110	Distillate fuel oil no. 2	124	4			7	1				49	1883	138
111	Residual oil no. 6												
112	Residual oil no. 6												
113	Residual oil no. 6												
114	Distillate fuel oil no. 2	2	0			0	0				1	33	2
116	Residual oil no. 6												
118	Crude oil (RVP 5)	2	80	95		7	83	0	1		43	6006	20
119	Gasoline (RVP 10)	5	128	17		12	110	0	2	2160	156	14975	49
120	Residual oil no. 6												
121	Gasoline (RVP 10)	1	15	2		1	13	0	0	244	18	1703	6
201	Asphalt												
202	Asphalt												

USERID	CONTENTS	1,2,4-Trimethylbenzene	Benzene	Cyclohexane	Ethanol	Ethylbenzene	Hexane (-n)	Isooctane	Isopropyl benzene	Methyl-tert-butyl ether (MTBE)	Toluene	Unidentified Components	Xylene (-m)
200	Asphalt												
203	Asphalt												
210	Distillate fuel oil no. 2	19	1			1	0				7	282	21
LR03	Jet kerosene		1			4	2				12	166	8
LR04	Gasoline (RVP 10)	1	14	2		1	12	0	0	234	17	1632	5
LR05	Gasoline (RVP 10)	1	19	3		2	17	0	0	325	24	2273	7
LR06	Jet kerosene		1			5	3				14	204	10
LR07	Distillate fuel oil no. 2	6	0			0	0				2	93	7
LR08	Methyl-tert-butyl ether (MTBE)									7658			
LR09	Distillate fuel oil no. 2	27	1			2	0				11	406	30
LR10	Gasoline (RVP 10)	1	20	3		2	17	0	0	338	25	2342	8
LR11	Gasoline (RVP 10)	6	160	22		14	139	0	2	2711	196	18791	61
LR12	Residual oil no. 6												
100	Hydrous ethanol				20367								
400-D1	Anhydrous ethanol				347								
400-D2	Anhydrous ethanol				95								
400-M	Anhydrous ethanol				658								
400-S	Anhydrous ethanol				3425								
101U	VGO/CGO [Residual oil no. 6]	5	0			0	0				2	101	5
102U	VGO/CGO [Residual oil no. 6]	5	0			0	0				2	92	5
103U	Crude oil (RVP 5)	1	59	70		5	61	0	1		32	4469	16

USERID	CONTENTS	1,2,4-Trimethylbenzene	Benzene	Cyclohexane	Ethanol	Ethylbenzene	Hexane (-n)	Isooctane	Isopropyl benzene	Methyl-tert-butyl ether (MTBE)	Toluene	Unidentified Components	Xylene (-m)
118U	Crude oil (RVP 5)	2	80	95		7	83	0	1		43	6006	20
122U	CCR feed [Distillate fuel oil no. 2]	2	0			0	0				1	41	3
123U	Diesel intermediate [Distillate oil no.2]	17	1			1	0				7	255	19
124U	Crude oil (RVP 5)	1	59	70		5	61	0	1		32	4410	15
125U	Sour water												
LR04UE	Gasoline (RVP 11)	1	15	2	0	1	13	0	0		18	2183	6
LR05UE	Gasoline (RVP 11)	1	21	3	0	2	18	0	0		25	3040	8
LR105UE	Gasoline (RVP 11)	1	22	3	0	2	19	0	0		26	3164	8
LR10UE	Gasoline (RVP 11)	1	22	3	0	2	19	0	0		27	3146	8
LR11UE	Gasoline (RVP 11)	6	173	23	0	16	149	0	3		211	0	66
104UE	Gasoline (RVP 11)	6	177	24	0	16	153	0	3		217	25871	67
107UE	Gasoline (RVP 11)	6	155	21	0	14	134	0	2		190	22645	59
119UE	Gasoline (RVP 11)	5	138	19	0	12	119	0	2		169	20120	52
121UE	Gasoline (RVP 11)	1	16	2	0	1	13	0	0		19	2278	6
	Total before Upgrade	212	1,036	346	24,892	143	937	2	15	22,940	1,299	115,566	645
	Total After Upgrade	241	1,037	347	24,892	145	938	2	15	22,940	1,312	116,166	678
	Total After Upgrade (all E10 Gasoline, no MTBE)	238	954	336	24,894	138	866	2	14	1,403	1,211	102,217	647

Table 6-10: VOC Emissions from Product Loading (Existing and After the Upgrade)

Product	Mode	Volume	Pollutant	Emission Factor	Annual Emissions	Comments	AP42 Reference
		US Gallons		lb/10^3 US gallons	tonne		
LPG	Truck	37,758,000		NA			
Gasoline	Ship	17,472,000	VOC	3.40	26.95	Gasoline: Barge Loading - Average Tank Condition	Table 5.2-2
Gasoline	Truck	96,222,000	VOC	5.00	218.23	Gasoline: Submerged Loading (Normal Service)	Table 5.2-5
			Benzene	0.0718	3.13	Gasoline: Submerged Loading (Normal Service)	
Jet Fuel	Ship	30,576,000	VOC	0.013	0.18	Kerosene: Loading Barges	Table 5.2-6
Jet Fuel	Truck	18,816,000	VOC	0.016	1.37	Kerosene: Submerged Loading (Normal Services)	Table 5.2-5
ADO,IFO	Ship	254,100,000	VOC	0.012	1.38	Distillate Oil: Loading Barges	Table 5.2-6
ADO,IFO	Truck	54,096,000	VOC	0.014	0.34	Distillate Oil: Submerged Loading (Normal Service)	Table 5.2-5
HFO	Ship	165,480,000	VOC	0.00009	0.01	AP 42 Table 5.2-6	Table 5.2-6
HFO	Truck	24,444,000	VOC	0.0001	0.00	AP 42 Table 5.2-5	Table 5.2-5
HFO	Pipeline	35,700,000		NA			
Asphalt	Truck	6,678,000		NA			

HFO Heavy fuel oil
ADO Automotive diesel oil
IFO Fuel oil

6.3.1.3.4 Other Fugitive Emissions

Fugitive VOC sources at the Petrojam refinery arise from non-point sources such as processing units, various equipment components (valves, pump seals, flanges, compressors, sampling connections, open-ended lines), oil water separators, process drains. Estimates of emissions from these sources require data on the numbers of these items (valves, flanges, compressors etc.) and corresponding emission factors. Data on the numbers of various pieces of equipment components at the Petrojam refinery are not available. The per component estimates of VOC releases are highly dependent on maintenance (leak detection and repair) practices and thus have large uncertainties.

In the absence of refinery-specific data on the numbers of components, VOC emission estimates can be made based on assumptions of the numbers of components present in typical full scale refineries. For example, US provides EPA estimates for the numbers of valves, flanges, pump seals and compressor seals and the associated daily emissions from a full scale 330,000 bbl/d refinery without any emission controls (US EPA, 1995). Such estimates applied to the Petrojam refinery (i.e., scaled to 36,000 bbl/d) will very likely overestimate the emissions since the existing Petrojam Refinery has few of the processing units found in a full scale refinery.

In order to provide some context (order of magnitude) for the existing refinery, the VOC emissions from the existing processing units, component leaks (valves, flanges etc.), cooling towers, drains and oil/water separator from full scale 36,000 bbl/d refinery would be ~1100 tonne/year. This would be ~40% of the emissions from storage tanks at the Petrojam refinery. Estimates of the emissions from the separator would be about 1,400 tonnes/year.

For the upgraded refinery (whose component equipment count would eventually be known once the full design has been completed), the use of current component equipment technology and wastewater treatment would result in fugitive emissions that would be considerably less that those derived from AP42 emission factors.

6.3.1.3.5 Greenhouse Gas Emissions

Emissions of the direct greenhouse gases (GHGs) CO_2, N_2O and CH_4 for the existing refinery and after the upgrade are shown in Table 6-11.

Estimates were based on combustion of heavy fuel oil, pipestill bottoms, refinery gas and flaring. Pipestill bottoms were assumed to have the same composition and hence emission factors for the GHGs as heavy fuel oil and similarly, flare gas was assumed to be the same as refinery gas.

Table 6-11 Petrojam's Greenhouse Gas Emissions Before and After the Upgrade

	Annual Emissions (Gg)		
Scenario	**CO_2**	**CH_4**	**N_2O**
Existing	151.9	0.0045	0.00078
After Upgrade	279.4	0.0107	0.00213

Although the CO_2 emissions after the upgrade will be ~84% more than those from the existing refinery, Petrojam's emissions would be only 2.0% of Jamaica's national CO_2 emissions (13,956 Gg in 2005). Jamaica's emissions are only about 0.05% of global emissions (27.2 x 10^6 Gg in 2005). Hence, although CO_2 emissions will have the largest spatial "reach" i.e., global, the impact on the global scale will be negligible.

6.3.1.3.6 Fugitive Emissions from Coke Production and Handling

The handling systems for the Petcoke to be produced by the Delayed Coker Unit are in two sections: Inside the Battery Limit (ISBL) and Outside the Battery Limit (OSBL).

Coke produced in the delayed coker drums[6] is cut and falls under the drum. The coke is then moved by front end loaders to a dewatering section on the coke pad. Front end loaders move the de-watered coke to a crushing system (feeder-breaker) located on the coke pad. The crushed coke is transported by a closed conveyor system to JPS for use in their co-generation facility. The system which is designated by US EPA as SCC 30601301, is illustrated in Figure 6-4 and is described below.

Inside Battery Limit

Green petroleum coke is cut and removed from each drum by high pressure water. The coke discharges from the drum by gravity via a chute system in front and below the coke drums to a maze area where coke fines and water is removed from the coke.

After the fines are removed, the front end loader moves the coke to another section of the coke pad for de-watering. After the coke is adequately dewatered, the front end loader moves the coke by feeding it into the crushing system. The crushed coke (nominally 2" diameter) exits the crushing system via a chute and by gravity to an Outside Battery Limit conveyor system.

<u>Equipment:</u>

Front End Loader: Caterpillar CAT 962 or equivalent

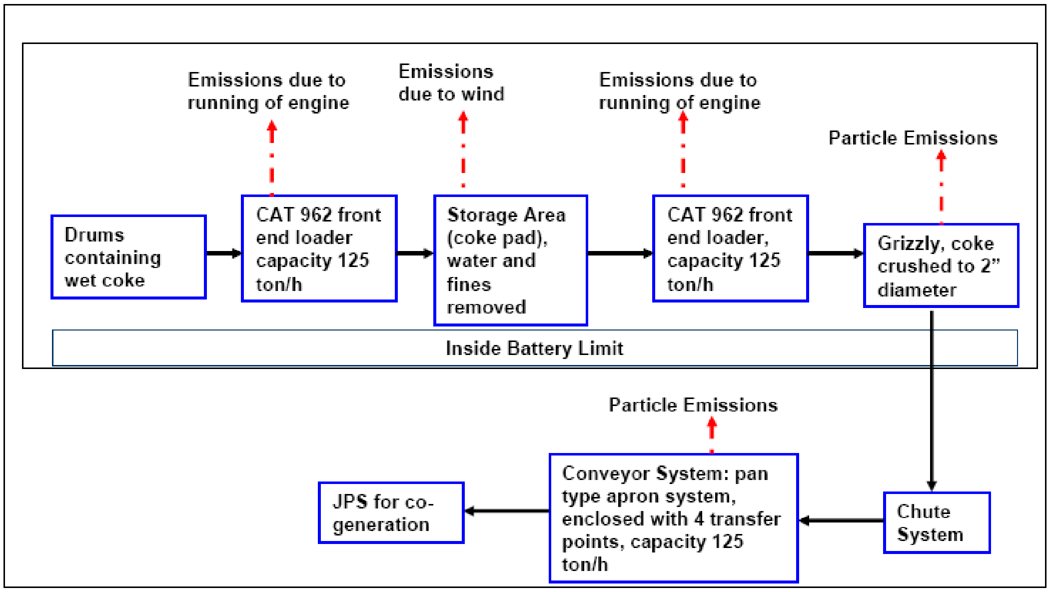
Crushing System: Stamler Feeder Breaker with inlet hopper and 10" X 10" grizzly section. Capacity 125 Short Tons per hr.

Outside Battery Limit

Crushed petcoke from the ISBL crushing system falls via a chute system on to a pan-type closed conveyor system which transports the 2" coke offsite to JPS. The conveyor system has four transfer stations. The conveyor which has a capacity of 125 short tons per hour, runs north of the DCU then north-east along the sea-side boundary of the Industry Loading Rack over to the south section of the JPS facility. The apron system is used to transport the coke with minimum spillage and is covered to minimize dust dispersion.

[6] A minimum of two drums is required. While one drum is decoked the other is used in the production of coke.

Figure 6-4 Emission Sources From Processes in the Manufacture of Pet Coke



Emissions from Drum Unloading

The unloading of coke from drums does not produce particulate emissions because the coke is unloaded as wet slurry.

Emissions due to CAT 962 Front End Loader

The unit will use Caterpillar CAT 962 or equivalent front end loader to move the wet coke from the drums and from the storage area to the grizzly. USEPA AP 42, 5th Ed., Table 3.3-1 (Emission Factors for Uncontrolled Gasoline and Diesel Industrial Engines) were used to estimate the emissions such as NOx, CO, SOx and PM10.

The specifications for CAT 962H were used. CAT 962H has a gross horsepower of 230 HP. The various emissions are summarized in Table 6-12.

Table 6-12 Emissions from CAT962H

Parameter	NOx	CO	SOx	PM_{10}
Emission Factor (lb/hp-hr)	0.0310	0.0067	0.0021	0.0022
Emission, lb/hr	7.13	1.54	0.47	0.51
Emission, g/s	0.898	0.194	0.059	0.064

The maximum one-hour emission rate was considered by assuming that the loader will be in operation continuously for at least one hour. If the time of continuous operation is less, this estimate would be conservative relative to regulations (that is the estimate is more than the actual).

Storage Area Emissions

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage. Particle emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and load out from the pile.

The data needed for calculating PM emissions from a storage area is the amount of coke loaded and unloaded. Historical constants and meteorological data required include the coke moisture content and the monthly average wind speed.

PM (ton/day) = Coke loaded (ton/day) x EF (lb PM/ton coke)

where:

EF = (k) (0.0032) $[(u/5)^{1.3}/(M/2)^{1.4}]$ lb/ton
(AP 42, 5th Ed., Section 13.2.4.3, Eq. 1)

k = particle size multiplier = 1.0 for PM, 0.35 for PM_{10} (AP 42, 5th Ed., 13.2.3)

u = mean monthly wind speed = 15 miles/hour

M = coke moisture content = 8% (assumed)

(Wind speed was obtained from the meteorological data of Norman Manley Airport, 1951-1980.)

EF_{PM} = (1) (0.0032) $[(15/5)^{1.3}/(8/2)^{1.4}]$ lb/ton = 0.0019 lb/ton coke

With a throughput of 125 short ton/hr, the worst case scenario was assumed to be loading and unloading totalling 250 short ton/hr.

Hence, PM = 0.0019 lb/ton x 250 short ton/hr x 0.89 ton/short ton
= 0.423 lb/hr = 0.053 g/s

PM_{10} = PM x 0.35 = 0.019 g/s

Coke Crushing

According to AP 42, 5th Ed., 11.19.2.1, the emission through a grizzly feeder crusher is ND (not detectable) for both PM and PM_{10}.

Conveyor System

Since conveyor systems are enclosed, only emissions at the transfer points have been considered. According to AP 42, 5th Ed., 11.19.2.2 the controlled emission factor for PM_{10} for conveyor transfer points is 0.000045 lb/ton. There are four transfer points and based on the conveyor capacity (125 ton/h), the maximum emission rate is 0.003 g/s.

Spalling Decoking

At Petrojam, the coke heater will be de-coked by online spalling at 6-9 months intervals depending on the rate at which the furnace tubes coke.

Online spalling is a process of removing the coke build up in the furnace tubes by replacing the process fluid through the tubes with steam and does not require any use of air. The tubes are then subjected to series of controlled heating and cooling to remove the coke build up.

During pigging, steam is also injected into the furnace tubes but a "studded pig" is pushed through the tubes as well that scrapes off the coke without scratching the tube surface. No air is used in this process either. Because of the infrequent spalling operation, any emissions during the spalling process will be considered negligible.

Lead Emissions

Since there is an emission factor for lead (Pb) for coke loading and storage estimates of lead emissions were made. The lead emissions are calculated by multiplying the PM emissions by a reference lead concentration for green coke dust from petroleum refining. The mass of Pb emitted can be determined from the following equation:

Lead, g/s = PM (g/s) x EFPb (ppm) x (10^{-6} /ppm) where: EFPb = Pb in pet coke = 100 ppm = 0.010 wt% (EPA Air Emissions Species Manual, profile # 26207).

Summary of Coke Production and Handling Emissions

Table 6-13 summarizes all the fugitive emissions from coke production and handling operations. The total PM emissions are only 0.06 g/s and are negligible (less than 0.4 %) when compared with emissions from the Petrojam point sources after the upgrade (15.5 g/s). Lead emissions (2 µg/s) are also negligible. Similarly, emissions of NOx, CO and SO_2 from coke production and handling are negligible and were not included in the modelling of sources after the upgrade.

Table 6-13 Summary of Fugitive Emissions

Emission Source	NOx g/s	CO g/s	SOx g/s	PM g/s	PM_{10} g/s	Lead g/s
Drum Unloading	-	-	-	-	-	-
Loader engine operation	0.898	0.194	0.059		0.064	-
Storage Area	-	-	-	0.060	0.019	$2.0x10^{-6}$
Coke Crushing	-	-	-	-	ND	ND
Conveyor System					0.003	-
Spalling Decoking	-	-	-	-	-	-
Total	0.898	0.194	0.059	0.060	0.086	$2.0x10^{-6}$

6.3.1.3.7 Air Dispersion Modelling

Air dispersion modelling of Petrojam and other sources in the Kingston was conducted according to the methods set out in the NRCA *Guideline Document (NRCA, 1999)*. Two separate cases were modelled, namely, a) the existing situation and b) the situation after the upgrade. In both cases, all of the point sources in the airshed were modelled. The model allows the determination of the contributions of all Petrojam sources separate from the contributions from all other sources.

Model predictions are provided for sulphur dioxide (SO_2), nitrogen oxides (NOx as nitrogen dioxide NO_2), total suspended particulate matter (TSP) and carbon monoxide (CO).

The current version (0726) of the AERMOD and associated models (AERMET and AERMAP) were used for the modelling. The model domain (see Figure 6-5) was 35 km in the east–west and 23 km north-south directions centred near the Petrojam refinery. Model predictions were made at up to 3665 receptors. The receptors included the intersections of grids a) over the entire domain (35 km x 23 km) with a spacing of 1000 m; b) a nested grid consisting of three squares with sides 7 km, 5 km and 3k with spacings of 500 m between 5 and 7 km, 200 m between 3 and 5 km and 100 m up to 3 km from a point near the centre of the Petrojam refinery; c) fenceline receptors spaced every 50 m; and d) a two-tiered fenceline grid 100 m and 200 m from the fenceline with spacings of 50 and 100 m. There were also 132 “special receptors” comprising schools, hospitals and health centres and ambient monitoring stations.

The key model inputs were as follows:

- Information for all point sources in the airshed (e.g., location, emission rates, stack height, diameter, and the exit temperature and velocity of stack gases)
- The dimensions (length, width and height) of buildings near to sources on the Petrojam site
- One (1) year of hourly surface and up to twice daily upper air meteorological data from the Norman Manley International Airport (NMIA) which is close to the refinery and is therefore representative of the meteorological conditions at the Petrojam site;
- Terrain heights at all receptor locations over the entire domain to take into account complex terrain in the model domain; and
- Land use types within a 3 km radius of the Petrojam refinery.

Predictions of SO_2, NO_2, TSP and CO concentrations were made for averaging periods (1 h, 8 h, 24 h or annual as the case may be) that correspond to those specified for the respective Jamaican National Ambient Air Quality Standards (JNAAQS). The maximum predicted concentrations plus the background concentrations were compared with the JNAAQS and are summarised in Table 6-14 for the existing sources and Table 6-15 for sources after the upgrade. Included in these tables are the emission rates for Petrojam sources alone and all sources (including Petrojam’s) in the airshed and the corresponding highest model predictions and the locations where they are predicted to occur.

Figure 6-5 Model Domain for the Kingston Airshed

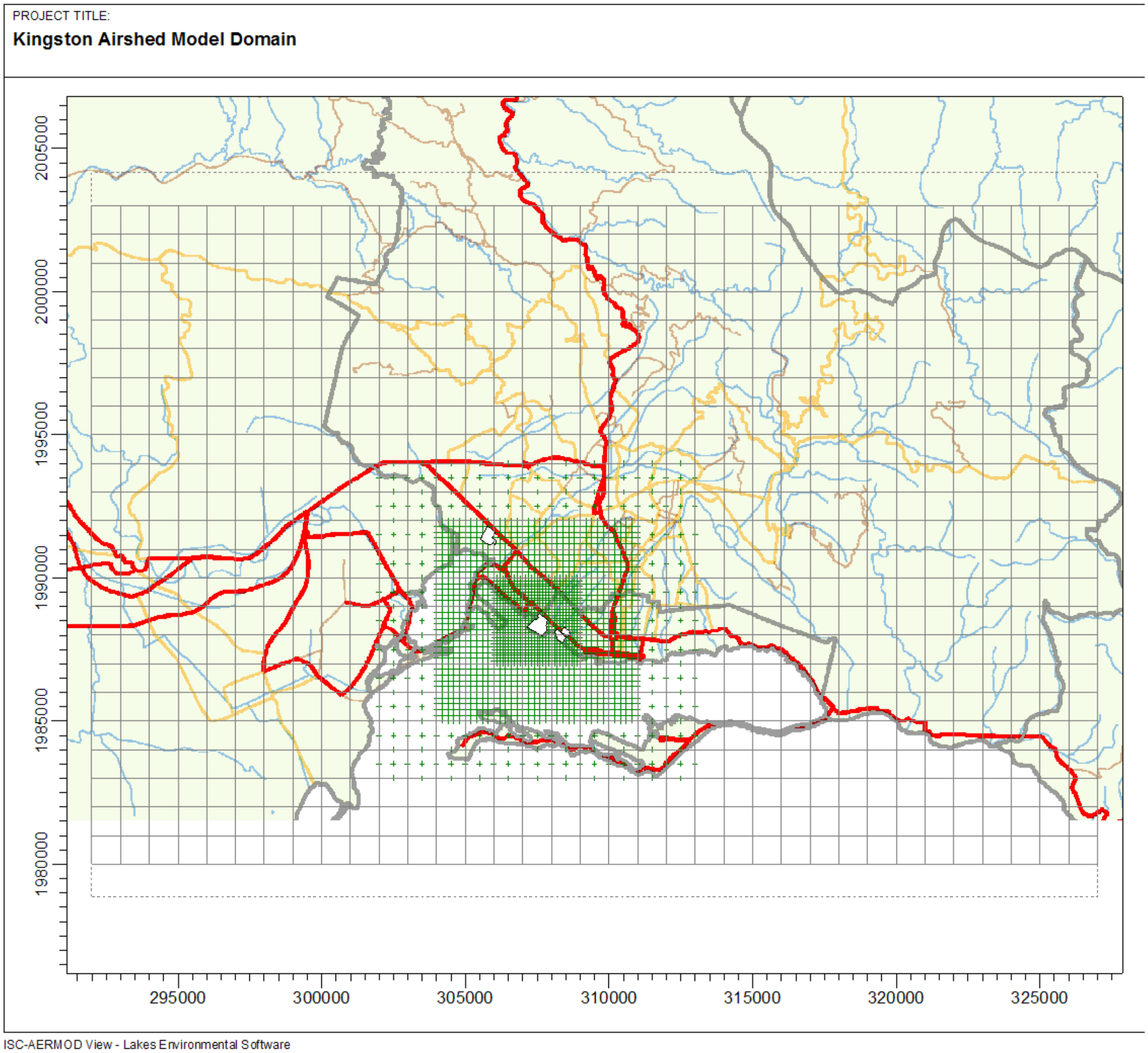


Table 6-14 Summary of Dispersion Model Predictions for the Existing Kingston Airshed Sources

Pollutant	Source Group	Emission Rate (g/s)	Averaging Period	Ambient Air Quality Standard (μg m^{-3})	Background Conc.* (μg m^{-3})	Max Predicted Conc. (μg m^{-3})	Location	
							UTM E (m)	UTM N (m)
SO_2	Petrojam only	140	1 h	700	0	2239	308500	1993000
			24 h	280	0	551	307371.78	1988151.62
			Annual	60	0	96.6	307524.81	1988066.00
	All Sources	821	1 h	700	0	8610	314000	1989000
			24 h	280	0	648	308500	1988100
			Annual	60	0	174	305600	1991800
NO2	Petrojam only	7.94	1 h	400	0	86.2	313000	1991500
			Annual	100	0	0.960	307000	1988300
	All Sources	566	1 h	400	9	4375	314000	1989000
			Annual	100	20	80.3	308250	1988000
TSP	Petrojam only	7.50	24 h	150	14	35.7	307371.78	1988151.62
			Annual	60	45	6.23	307524.81	1988066
	All Sources	58.7	24 h	150	14	52.2	308500	1988100
			Annual	60	45	11.5	305600	1991800
CO	Petrojam only	1.59	1 h	40,000	NA	25.3	311500	1990500
			8 h	10,000	NA	9.83	307524.81	1988066.
	All Sources	565	1 h	150	NA	10434	314000	1989000
			8 h	60	NA	1740	314000	1989000

* Based on the Guideline Document
NA Not available

Table 6-15 Summary of Dispersion Model Predictions for Kingston Airshed Sources After the Upgrade

Pollutant	Source Group	Emission Rate	Averaging Period	Ambient Air Quality Standard	Background Conc.*	Max Predicted Conc.	Location			
		(g/s)		(μg m^{-3})	(μg m^{-3})	(μg m^{-3})	UTM E (m)	UTM N (m)	Distance #(km)	Direction #(º from North)
SO_2	Petrojam only	243	1 h	700	0	3332	309000	1996000	7.9	79
			24 h	280	0	704	307400	1988200	0.1	328
			Annual	60	0	110	307525	1988066	0.2	265
	All Sources	917	1 h	700	0	6423	314000	1989000	6.5	6
			24 h	280	0	710	307400	1988200	0.1	328
			Annual	60	0	146	307601	1988023	0.3	249
NO_2	Petrojam only	8.78	1 h	400	0	233	312750	1990420	5.7	22
			Annual	100	0	5.25	307629	1987893	0.4	252
	All Sources	5.46	1 h	400	9	2816	308300	1988000	0.8	199
			Annual	100	20	32.7	308500	1988100	1.0	190
TSP	Petrojam only	16.1	24 h	150	14	44.0	307400	1988200	0.1	328
			Annual	60	45	6.5	307525	1988066	0.2	265
	All Sources	65.8	24 h	150	14	49.8	308500	1988100	1.0	190
			Annual	60	45	8.4	307601	1988023	0.3	249
CO	Petrojam only	4.74	1 h	40,000	NA	122	311500	1990500	4.6	29
			8 h	10,000	NA	17	311500	1990500	4.6	29
	All Sources	569	1 h	40,000	NA	1060	316000	1988000	8.5	182
			8 h	10,000	NA	396	307855	1988030	0.4	214

* Based on the Guideline Document
\# Relative to the F201 stack

The model predictions show that predicted SO_2 concentrations due to Petrojam sources alone are of potential concern both for the existing situation and after the upgrade since the highest predicted concentrations exceed the corresponding NRCA air quality standards. Unfortunately there are very limited ambient monitoring data with which model predictions can be compared.

The monthly average SO_2 concentration measured at the NEPA site in Cross Roads for 9 months between (October 2005 and June 2006) was in the range 30 to 37 µg m^{-3}. These data suggest an annual mean in the same range also. Model predictions at the same site gave an annual mean of 10 µg m^{-3} – a factor of three lower than the mean that can be estimated from the reported monthly means. Experience shows that model predictions agree better for the annual means but for hourly averaging periods model predictions for the highest hourly concentrations are considerably higher than measurements. It is feasible that in the current case the highest hourly measurements would be at least a factor of 10 lower than the model predictions. It is for this reason that long term continuous measurements for SO_2 (as well as for NO_2) are being implemented at three sites in the vicinity of the Petrojam and Hunts Bay facilities.

Model predictions for the highest 1h and 24 h SO_2 concentrations and for the annual mean SO_2 concentrations at the other receptors are given in Appendix 9.3. It should be noted that the highest predicted 1 h and 24 h concentrations are expected to be higher than measurements by factors of 3 to 10.

The model predictions for the highest 1 h and 24 h average concentrations due to Petrojam sources alone are shown in Figure 6-6 and Figure 6-7. Detailed analysis of the results shows that the 100 highest 1 h average SO_2 concentrations occur near midnight and at low wind speeds. The total number of times that the 1 h standard is predicted to be exceeded is shown in Figure 6-8. This shows that few (less than 5) high values occur near the maximum in Figure 6-6) while many more exceedances occur very near to the plant (see Figure 6-9). Because of the low frequency of the very high values it would be difficult to place a monitor to capture such events. On the other hand, placing a monitor where many more high values are predicted to occur will dramatically increase the likelihood of obtaining higher measurements. The longer term monitoring planned will locate three continuous monitoring stations closer to the Petrojam and Hunts Bay facilities.

Figure 6-6 Model Contours for the Highest Predicted 1 h Average SO_2 Concentrations – Petrojam Sources after Upgrade

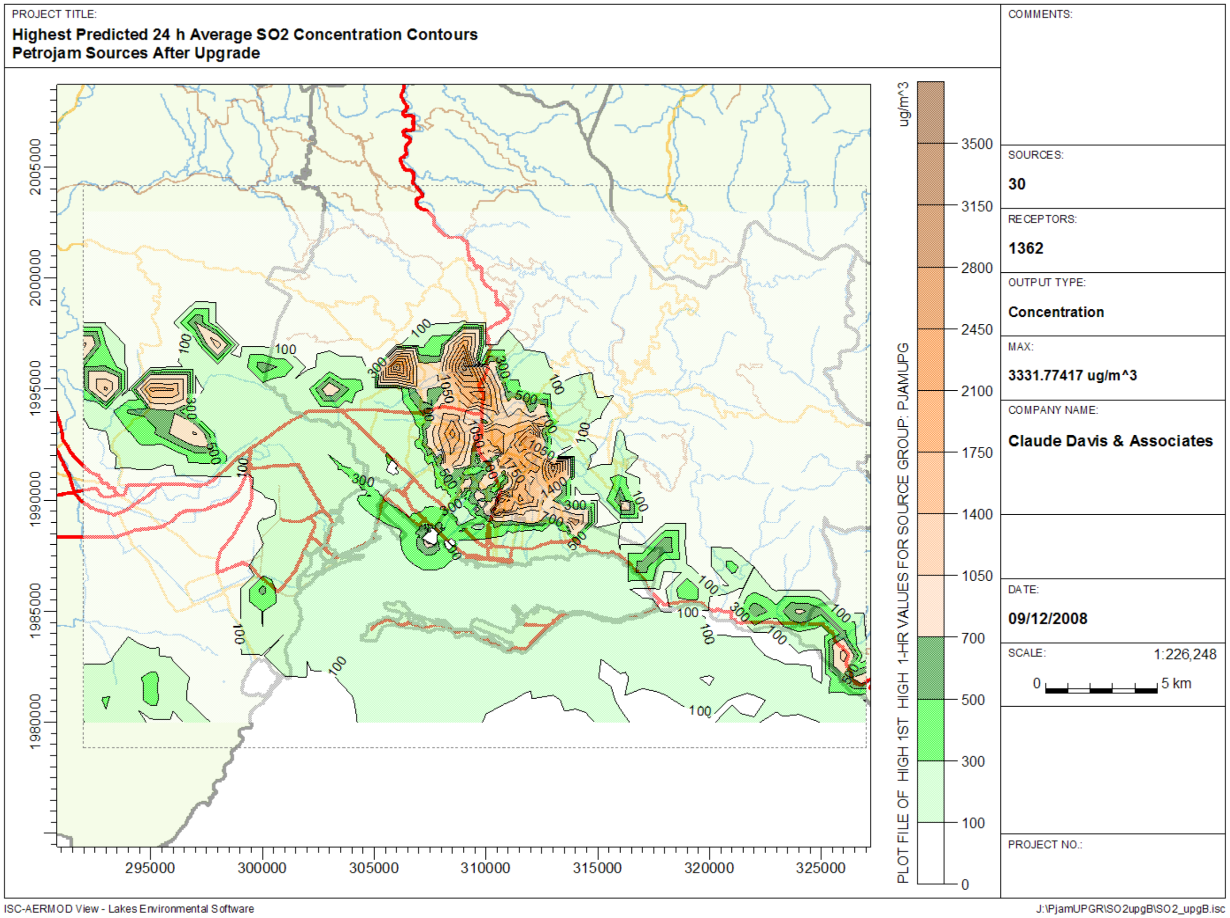


Figure 6-7 Contours for the Highest Predicted 24 h Average SO_2 Concentrations – Petrojam Sources after Upgrade

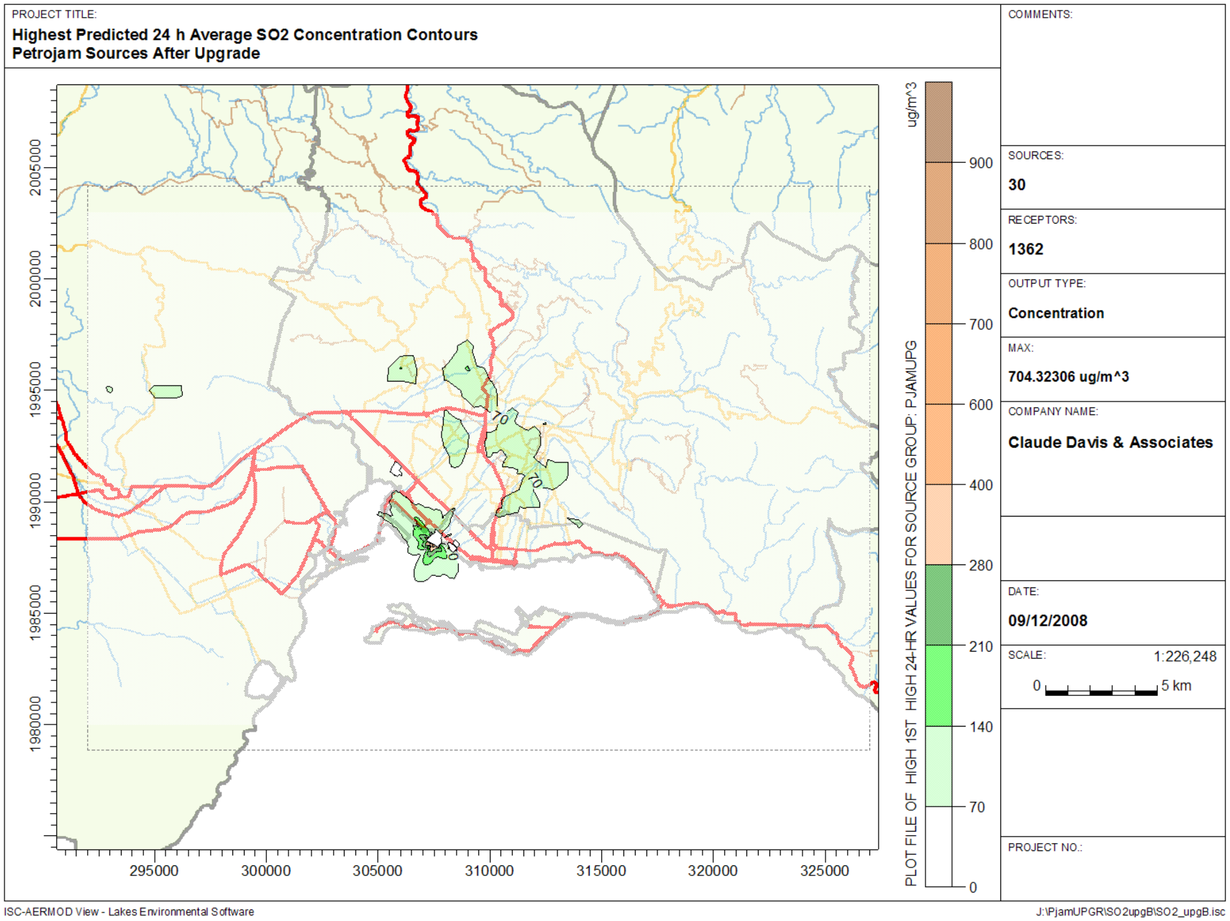
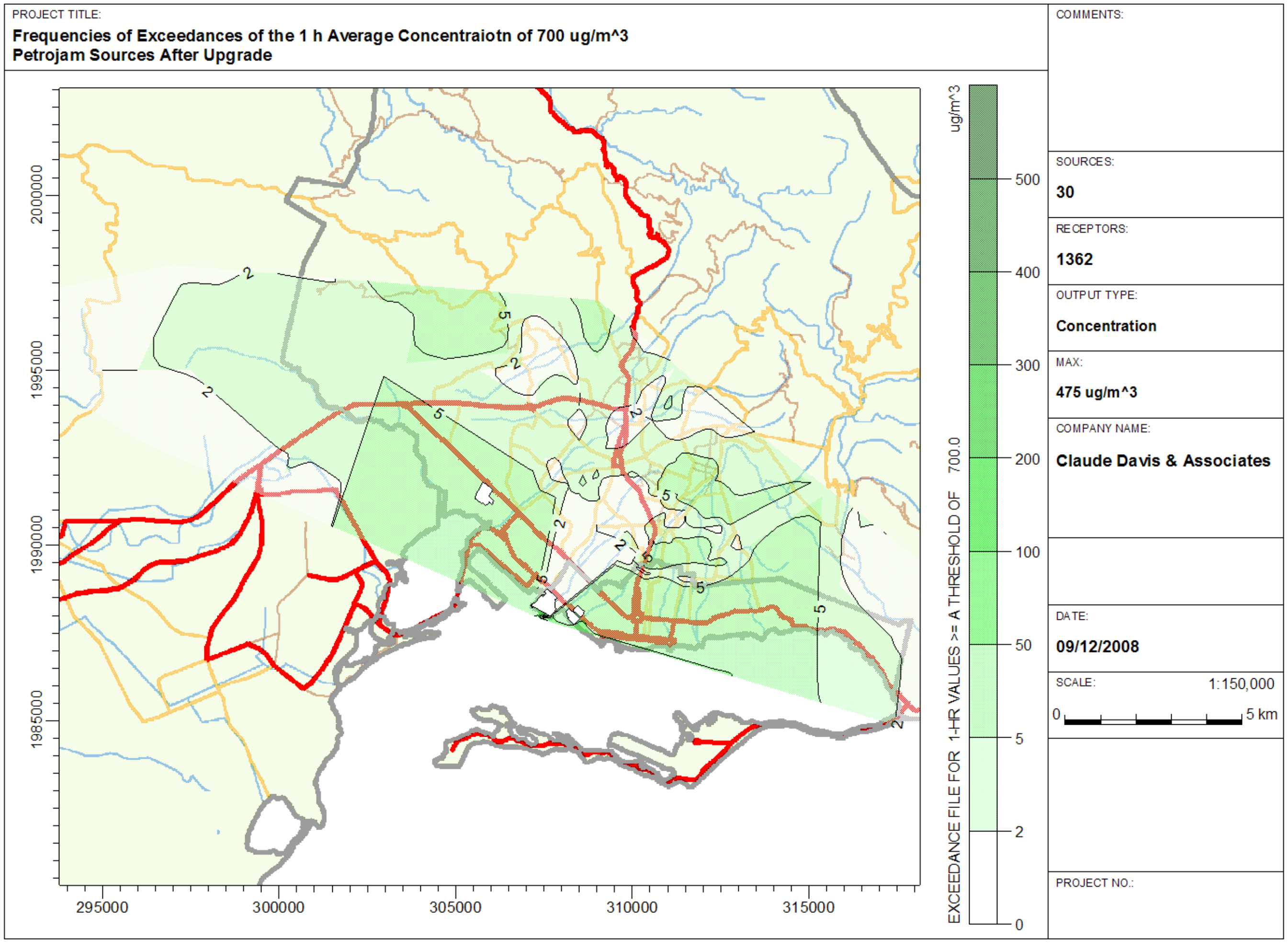


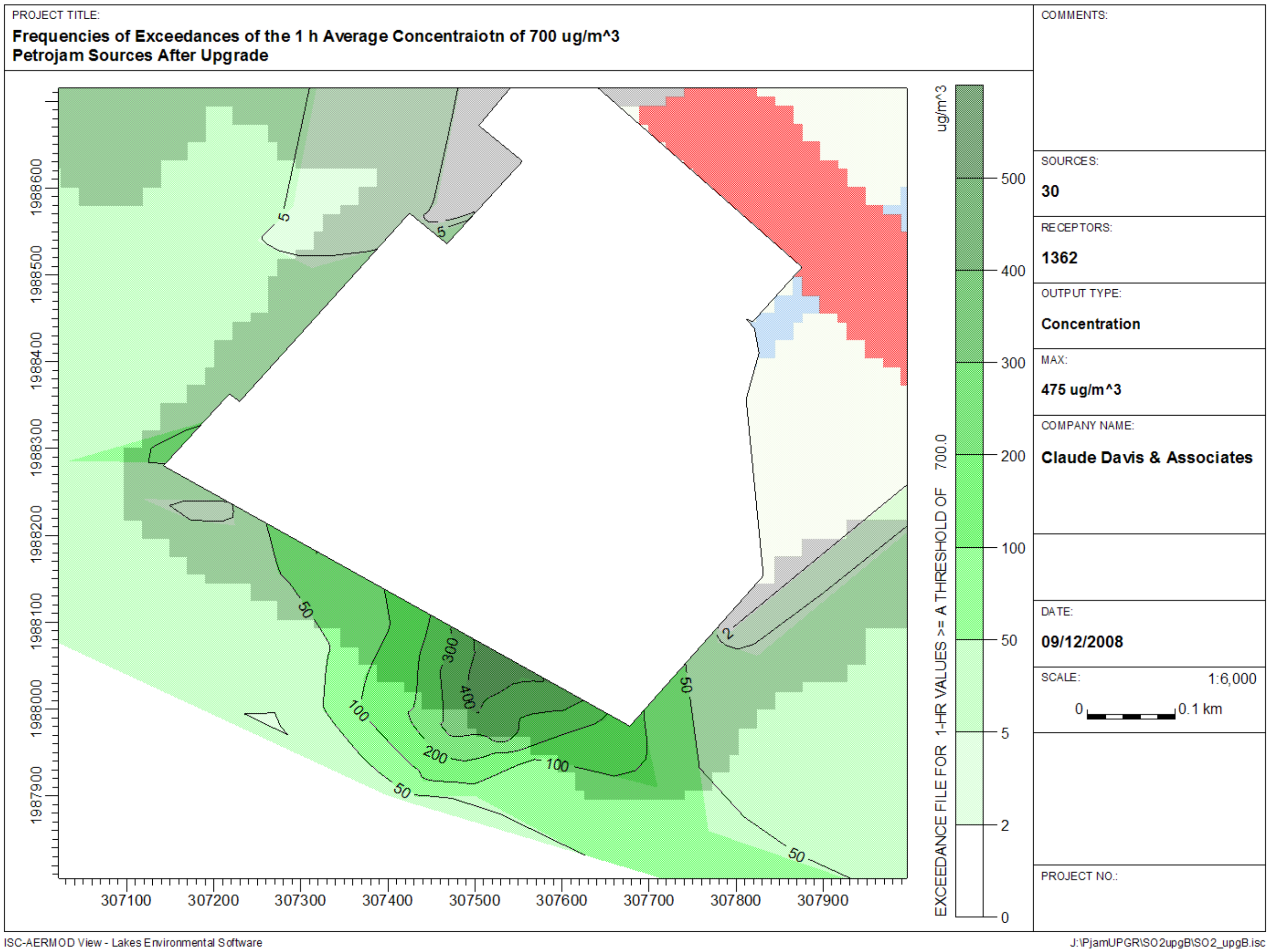
Figure 6-8 Frequencies of Predicted Exceedances of the 1 h Average SO_2 Concentration of 700 µg m^{-3} – Petrojam Sources After Upgrade



ISC-AERMOD View - Lakes Environmental Software

J:\PjamUPGR\SO2upgB\SO2_upgB.isc

Figure 6-9 **Frequencies of Predicted Exceedances of the 1 h Average SO_2 Concentration of 700 µg m^{-3} – Petrojam Sources After Upgrade (Near the Petrojam Site)**



6.3.1.3.8 Is the change in air quality significant?

The NRCA Air Quality Regulations and *Guideline Document* define impacts as "significant" when the increment in the predicted average concentration of SO_2, TSP or PM_{10} or NO_2 is greater than an annual average of 20 µg m^{-3} or a 24-hour average of 80 µg m^{-3} and when such predictions are made using an approved air dispersion model. For CO the levels are 2000 µg m^{-3} for a 1 hr average and 500 for a 8 hour average. The *Guideline Document* also indicates that a compliance plan (i.e., mitigation) be submitted when impacts are significant.

The results of the dispersion model in relation to the test of significant impact are shown in Table 6-16. The data are somewhat inconclusive since the SO_2 and NO_2 results for the 24 hour show that the changes are significant but the results for the annual average indicate that the impacts of the upgrade are not significant. Continuous monitoring is proposed as the first step (see Section 7.2).

Table 6-16 Summary of Dispersion modelling Results to Test Significance of Air Quality Impacts

Pollutant	**Averaging Period**	**Maximum Predicted (µg m^{-3})**		**Increment (µg m^{-3})**	**Significance Criterion (µg m^{-3})**
		Existing	After Upgrade		
SO_2	24 hr	551	704	153	80
	Annual	97	110	13	21
TSP	24 hr	36	44	8	80
	Annual	6	6.5	1.5	21
NO_2	1 hr	86	233		
	24 hr#	50	135	85	80
	Annual	1	5	4	21
CO	1 hr	25	122	97	2000
	8 hr	10	17	7	500

Estimated from the 1 hr results based on equation 9-1.

6.3.1.4 Health Risk Assessment

The Terms of Reference for the EIA include the following item related to health risk assessment:

> *"**Identify** the significant environmental and public health/safety issues of concern and indicate their relative importance. These should include the occupational exposure, health and safety measures and population exposure in the appropriate study areas and changes and or enhancements in emergency response plans."*

The population exposure to chemicals in the emissions from the Petrojam refinery was assessed by conducting a human health risk assessment. The purpose of the health risk assessment will be to:

a) identify human health risks due to the existing refinery operations, and

b) determine any incremental risks due to the refinery upgrade.

The NRCA *Guideline Document* suggests that a risk assessment is required for proposed Major Facilities that emit more than 10 tonnes/y of any priority air pollutant (PAP) or more than 25 tonnes/year of any number of PAPs). Five of the VOCs that were measured during the monitoring program for this EIA are NRCA Priority Air Pollutants and their annual emissions (see Table 6-9) are each less than 10 tonnes and their combined emissions are also less than 25 tonnes.

Nevertheless, a screening risk assessment was conducted for benzene since a) it has the lowest limit of the compounds included in ambient VOC measurements; and b) some of the 24 h average concentrations that were measured in the vicinity of the Petrojam site were higher than the 24 h limit).

The risk assessment entailed examination of the inhalation risk for benzene based on dispersion modelling of the benzene sources in order to estimate the exposure at a number of receptors. Details of the risk assessment are provided in Appendix (Section 9.4) but the results are summarised as follows.

The health risk assessment identified benzene as the compound of concern based on ambient measurement of TSP, VOCs as well as SO_2 and NO_2. Although model predictions suggest that ambient air quality standards could be exceeded, the measured SO_2 concentrations suggest otherwise. The TSP and SO_2 concentrations that were measured in the vicinity of the Petrojam site during the EIA are well below the applicable air quality standards. In view of the limited ambient SO_2 measurements and the model predictions which took into consideration the emissions from nearby JPS Hunts Bay electricity generating station, an ongoing joint (between Petrojam and JPS) monitoring program to measure SO_2 (as well as NO_2 and PM_{10}) is being undertaken. The monitoring program together with additional modelling will definitively assess the impacts due to SO_2 emissions.

Although the upgrade will result in an increase of ~9 g/s (243 tonne/y) of total particulate emissions there will be no change in the highest predicted TSP concentration. [This is because the new sources after the upgrade have taller stacks and the highest predicted concentrations from these sources occur further downwind and have lower maximum concentrations.] Because of this there will be no incremental risk from particulate emissions.

The VOC monitoring undertaken during the EIA entailed measurement of 18 compounds consisting of two chlorinated compounds that are found in consumer products or used in commercial/industrial products or applications, two compounds emitted from vegetation or used in consumer products and hydrocarbons associated with gasoline and petroleum refining . When daily average measurements of these compounds were compared with standards or limits established by various jurisdictions, benzene was the only compound that appeared to exceed the limit (see Table 6-17).

More careful examination of the monitoring data indicated that there was a single day on which the limit for benzene appeared to have been exceeded and the data (for benzene and the compounds associated most strongly with gasoline) which suggested that the samples were contaminated with gasoline on that day.

In spite of the above, benzene was assumed to be a compound of concern. Examination of the sources of benzene emissions indicate that the loading of gasoline into trucks at the loading rack is by far the main source of benzene emissions. Other sources are from storage tanks (the second largest source) and some point sources (those that burn fuel oil or pipestill bottoms which emit relatively negligible amounts of benzene).

The upgrade will not change the total amount of gasoline that is loaded at the loading rack – since the increased gasoline production by the upgraded refinery will result in a similar reduction in imported gasoline. Because of this it was not necessary to model benzene emissions after the upgrade in the health risk assessment. Since benzene is classified as a Group 1 carcinogen (carcinogenic to humans) by the International Agency for Research on Cancer2 and a Group A carcinogen (human carcinogen) by the USEPA. As such, benzene was assessed for both non-carcinogenic and carcinogenic effects in the risk assessment.

Table 6-17 Comparison of Measured VOCs with Limits in Selected Jurisdictions

Chemical (Measured Average Daily Concentration range in µg m^{-3})	CAS No.	Concentrations in µg m^{-3}				Jurisdiction (Basis)
		10 min	1 h	24 h	Annual	
Benzene	71-43-2				1	NRCA
(25 - 85)			54		1.4	Texas ESL (H)
				30	0.13	US EPA
			$1300^{\#}$			ARB (AI)$^{\#}$ 6 hr avg
			60			ARB (CI)
p-Xylene	106-42-3		5750	2300		NRCA
(2.6 – 26)			550		55	Texas ESL (H)
Tetrachloroethylene	127-18-4		900	360		NRCA, Ontario (H)
(2.4 – 2.5)			2000		26	Texas ESL (H)
Trichloroethylene	79-01-6		57.5	23		NRCA
(2.2 – 2.9)				12	2.3	Ontario (H)
			540		54	Texas ESL (H)
Xylenes	1330-20-7		5750	2300		NRCA
(2.6 – 26) o		3000				Ontario (O)
(6.4 – 76) m+p				730		Ontario (H)
			3700		370	Texas ESL (H)
					180	Health Canada
1,3-Diethylbenzene (2.4 – 7.3)	141-93-5		2500		250	Texas ESL (H)
2,2,4-Ttrimethylpentane (3.9 – 5.2)	540-84-1					
2,2-Dimethylbutane (2.2)	75-83-2		3500		350	Texas ESL (H)
2-Methylheptane (2.6 – 14)	107-83-5		3500		350	Texas ESL (H)
2-Methylhexane (2.5 – 22)	591-76-4		3070		307	Texas ESL (H)
α –Pinene (2.1)	80-56-8		60		6	Texas ESL (O)
Decane	128-15-5		60,000			Ontario (H& O)
(3.0)			10,000		1,000	Texas ESL (H)
d-Limonene (2.5)	5989-27-5		1100		110	Texas ESL (H)
Heptane	142-82-5			11,000		Ontario (H)
(2.5 – 21)			3,500		350	Texas ESL (H)
Naphthalene	91-20-3	50		22.5		Ontario (H)
(2.7 – 4.2)			440		44	Texas ESL (H)
n-pentane (11 – 72)	109-66-0		3500		350	Texas ESL (H)
Octane	111-65-9	61,800				Ontario (O)
(2.6 – 9.1)			3500		350	Texas ESL (H)
Toluene	108-88-3			2,000		Ontario (O)
(13 – 89)			640		1200	Texas ESL (H)
					3800	Health Canada

O Odour; H Health; AI Acute inhalation (non-cancer) CI Chronic inhalation non-cancer

Comparisons between the measurements and the model predictions suggest that the model predictions are between 1 and 4 times greater than the highest measurements (when data for September 8 are excluded).

Risks associated with emissions from the refinery were estimated by comparing the exposure rates predicted by the model with established toxicity reference values (TRVs). These TRVs are provided as rates of exposure to which the receptor can be exposed without adverse human health effects. Risks are estimated by directly comparing the project-specific rate of exposure to the TRV. TRVs are established by regulatory agencies (e.g., USEPA, California Air Resources Board, Health Canada or the Ontario Ministry of the Environment) and are based on animal toxicity tests or human epidemiological studies.

The TRVs used were taken from the USEPA's Integrated Risk Information System (IRIS) and the California Air Resources Board. The reference concentration (RfC) was used to assess non-carcinogenic inhalation effects and inhalation unit risk (IUR) provided on IRIS and ARB to assess carcinogenic effects.

Generally, the RfCs provided by IRIS are estimates (with uncertainty spanning perhaps an order of magnitude) of daily continuous 24-hour exposure of the human population, including sensitive subpopulations, that is unlikely to cause adverse effects during a lifetime. Since IRIS and ARB provided TRV values, the lower (more stringent) value was used to evaluate the hazard quotient. Acute effects were assessed by comparing the highest predicted 1 hr benzene concentration to the acute reference value.

The hazard quotient (HQ), which is the ratio between the concentration to which a person is exposed and the RfC, is used to assess non-cancer hazards. Regulatory agencies concur that a hazard quotient value below one (1) is not significant – that is no adverse health effects would be expected (USEPA, 1989; Health Canada, 2004). A value of the HQ greater than one indicates that the exposure is higher than the RfC. However, because many RfCs incorporate protective assumptions in the face of uncertainty, an HQ greater than one does not necessarily suggest a likelihood of adverse effects. A HQ greater than one can best be described as indicating that a potential exists for adverse health effects.

In order to account for exposure pathways other than by air, 20% of the TRV is allocated for each pathway. Hence it is assumed that people are exposed to contaminants in soil (0.2), groundwater (0.2), air (0.2), food (0.2) and consumer products (0.2) for a total of 100% or 1. An apportionment factor of 0.6 for benzene was used because it may be present in air, soil and groundwater.

Cancer risks due to exposure to carcinogenic compounds are expressed by dose-response relationships and generally expressed as a unit risk estimate (URE) [also called the slope factor]. This is an upper bound estimate of an individual's probability of contracting cancer over a lifetime (assumed to be 70 years) of exposure to a concentration of one microgram of the pollutant per cubic meter of air (1 $\mu g\ m^{-3}$). The incremental cancer risks are calculated by multiplying the actual concentration to which someone is exposed by the URE or slope factor.

Regulatory agencies have used various levels to indicate what is a negligible cancer risk. A level of one-in-100,000 (or 1 x 10^{-5}) is considered negligible by Health Canada (2004). US EPA has typically used a range (e.g., 10^{-4} to 10^{-6}) for specifying the level for acceptable risk. For example in the 1996 and 1999 National-Scale Air Toxics Assessments (US EPA 2002 and 2006), US EPA looked for pollutants whose cancer risks were above 1 in a million (and whose non-cancer hazard levels were greater than 1.0). Exposures which are calculated to cause more than 1 in 10,000 excess cancers are considered to be of concern and may require action to reduce the exposure and resulting risk. The level or range selected depends on a number of factors.

In Ontario, the health risk for carcinogens is normally expressed as a "probability of occurrence". The Ontario Ministry of the Environment (MOE) air standards objective for carcinogens is to set the standard at an incremental risk of 1 in a million (or 10^{-6}) (MOE, 2005). In addition, the MOE generally sets an Upper Risk Threshold at a risk level of 10^{-4} for carcinogens. The concentrations corresponding to the upper risk thresholds are compound specific and are generally 10 times higher than the standard for non-carcinogens and 100 times higher than the standard for carcinogens. When measured or modelled concentrations result in incremental risks between 10^{-6} and 10^{-4} the basis for action takes into account the magnitude (concentration) and the frequency (e.g., the percentage of time in a year that concentrations above the standard occurs).

The model predictions were made at a number of sensitive receptors as well as at the stations at which benzene (and other VOCs) were measured. Note that one of the monitoring stations – called LR (for the loading rack) was actually on Petrojam's property and as such it should be treated as an occupational exposure station – but nevertheless it will be included in the health risk assessment.

At the special receptors, health risks associated with acute exposure to benzene remained significantly below the target HQ of 0.6 except for the receptor NW1. Similarly for chronic exposure – based on the highest predicted daily average benzene concentration, two receptors NW1 and LR have hazard quotients greater than 0.6.

Six of the 146 receptors – namely the VOC or TSP monitoring stations (LD, NW1, NW2, GRMX, and BH) as well as at the nearest residence to the northwest (NRNW) had incremental lifetime cancer risks (ILCR) that were greater than 1 in 1,000,000: the ILCR values at the remaining 123 non-occupational receptors (i.e., excluding those within Petrojam's property) are less than 1 in 1,00,000 and hence the exposures at these receptors are considered negligible. At 1 x 10^{-5} (1-in-100,000), Health Canada considers the risk to be essentially negligible. Five receptors NW1, NW2 and BH have incremental cancer risks between 10^{-5} and 10^{-6}. Only at the loading rack was the incremental lifetime cancer risk greater than 10^{-5}.

The frequencies with which exceedances of the 1h and 24 h limits occur at the five receptors range from 0.05% of the time to 2.0% of the time. This low frequency of occurrence would be likely to require much less urgent action in Ontario for example especially if the frequencies were based on measured values.

It is prudent to err on the side of caution and we recommend that the risks due to benzene exposure by the existing refinery should be examined further at receptors in the vicinities of the nearest residences (NRNW, NRNE and NRE), the loading rack (LR) and also at the NW1 and NW2 stations. The first step in such examination is to conduct additional ambient monitoring for benzene. In making the recommendation we are discounting a) the conservative (high) emission rates used in the model, b) the likelihood that the model over predicts, c) the loading rack site should be treated in an occupational exposure context and d) the conservative nature of the unit cancer risk factor.

It is however concluded that the upgrade will not pose any additional risks.

6.3.1.5 Vibration Impacts After the Upgrade

Vibration impacts that can arise from moving equipment (pumps, compressors, motors) are also unlikely to affect adjacent properties since such equipment will be located almost exclusively in the processing area (which is distant from adjacent properties). Of greater importance will be the impact of vibration on Petrojam's structures. Equipment suppliers will provide specifications for vibration and these are not currently available but are an important aspect of the design. Mitigation measures after the upgrade are described in Section 7.

6.3.1.6 Emergency Response Plans After the Upgrade

The upgrade will expand some of the existing processing units except for the asphalt plant. The upgrade will also include new processing units. The upgrade will also include a new air pollution control system to remove sour gases from various processes. The new units and pollution control systems will have their standard operating procedures which will need to be taken into account in updating some of the emergency response plans.

While the Process Safety Management program and the philosophy and objectives of the Health, Safety, and Environmental Management (HSEM) program will be retained there will need to be changes in the HSEM to reflect the physical changes as well as to introduce measures that are required for the new processing units. The implications of the upgrade for various aspects of the emergency response plans are summarised in Table 6 -18.

The upgrade will result in entirely new (except for revamped units and the asphalt plant) piping, valves, pumps etc., which will be much less subject to leaks and failure. However, it will be recommended that Petrojam institute more regular inspections of equipment and to implement a leak detection and repair program. This is addressed in Section 7.

Table 6-18 Implications of the Upgrade For Emergency Response Plans

Plan	Comments/Description	Upgrade Implications
Fire Emergency Plan	Defines Petrojam's role in responding to fires and defines the roles of relevant Government agencies (NEPA, ODPEM, Port Authority, NWA, JDF Coast Guard, JFB, NWC) and NGO'S.	For the new processes and tanks additional process and tank specific fire fighting equipment will be included in the design. Locations of assembly points will need to be revised/updated
Oil Spill Response plan	The plan addresses the full range of spills in Jamaican coastal waters, and particularly in the Kingston, Portland Bight and Montego Bay harbours. And is complementary and subordinate to the National Oil Pollution Contingency Plan. Includes cooperation and mutual aid with other petroleum marketing companies (ESSO, SHELL, TEXACO, and PETCOM) under the "Oil Pollution Control Committee" (OPCC). Upon request, PETROJAM will make its resources available to the JDFCG or OPCC	The increased number of ships and barges unloading and loading cargo (crude oil, refiner and semi refined product) i.e., frequency of calls will increase but oil spill response will not change significantly since the full range of spills is already covered.
International Ship and Port Security Code Plan (ISPS) plan	The ISPS is a code adopted by the International Maritime Organisation (IMO). It is designed to protect ports and international shipping against terrorism. The Port Authority of Jamaica has adopted the ISPS and all companies which use port facilities must be in compliance with the code.	Negligible. Although the increased frequency of calls for importation of crude oil and shipping of products will require a higher level of readiness, the plan should not change significantly.
Evacuation Plan	This plan complements and refers to all other plans that require evacuation. Includes specific procedures for the loading rack.	The upgrade will require updates and additions to account for new locations of staff and processing areas, assembly points etc. Locations of assembly points will need to be revised/updated

Plan	Comments/Description	Upgrade Implications
Civil Unrest	Includes procedures that will enable Petrojam to effectively prepare for and/or respond as needed to civil unrest that may impact on refinery operations.	None. The upgrade will not directly affect these procedures
Hurricane Preparedness and Response	The plan establishes the policy and procedures for protecting Petrojam personnel and facilities in preparation for hurricane- force weather.	None. Note that the design of the upgrade will take into account the structural requirements to withstand hurricanes. Locations of assembly points will need to be revised/updated
Earthquake Response Plan	Provides a framework for coping responsively to an earthquake and assigns responsibilities to meet the emergencies that may arise. This plan supports the National Earthquake Response Plan (Jamaica) and other plans used to respond to an earthquake at Petrojam Limited. The key objective is to save lives and minimise damage to equipment and property.	Although the upgraded refinery will have additional processing units, the policy will remain the same. Note that the design of the upgrade will take into account the structural requirements to withstand earthquakes. Locations of assembly points will need to be revised/updated

6.3.2 Biological Impacts After the Upgrade

6.3.2.1 Potential Terrestrial Impacts After the Upgrade

Potential terrestrial impacts are negligible since the site is a well developed industrial site and no changes in the habitat are likely. Activities such as improper management and/or storage/removal of maintenance debris could create breeding sites for pests and also lead to blockage of storm water drainage channels.

6.3.2.2 Potential Marine Impacts After the Upgrade

Potential marine impacts due to continued development activities are considered to be of high significance because of the potential for entry of petroleum products to an already impacted harbour ecosystem. The potential also exists for these products to be carried out of the harbour to impact reef systems immediately adjacent to Kingston Harbour. It should be noted that the reefs in this area are already highly stressed by excess nutrients and suspended solids in the water coming from Kingston Harbour. While the possible impacts of petroleum product toxicity and sedimentation / turbidity may not be as severe as would be the case with healthier reefs the relative impacts on these systems have the potential to be of critical importance to the survival of both harbour and reef systems. The upgraded wastewater treatment plant is designed to meet NEPA's trade effluent standards (including oil and grease) and will dramatically reduce the potential for oil from the upgraded refinery reaching the harbour. Because of this marine impacts from hydrocarbons after the upgrade would be reduced.

6.3.3 Socio-Economic Impacts After the Upgrade

The socioeconomic impacts after the upgrade of the proposed development include use, employment and community development/recreation.

6.3.3.1 National/Regional Development

Employment

It is estimated that over 185 new, permanent positions will be needed in the post-construction phase. There will also be increase demand for skilled and unskilled contract workers.

The extent to which members of the local community take advantage of the training opportunities afforded during the construction phase will provide opportunities for employment at Petrojam as well as in the spin off services and industries that the upgrade will generate. This will contribute to lower unemployment.

Land Use

There will be no change in land use after the upgrade since the proposed project will be entirely within the current property boundaries.

Traffic

The quantity of finished products that leave the site via tank trucks or ship (barges) should not increase. Some of the sulphur by-product for local use will be shipped by truck and the remained exported by ship.

After the upgrade there will be increased marine traffic for the importation of larger amounts of crude oil and for the export of vacuum gas oil and hydrocracker gas oil as well as sulphur.

The new product petcoke will be transported to the JPS Hunts Bay Plant, which is located immediately east of the site, via a dedicated conveyor belt system, and will therefore not impact any road or marine transportation networks.

Community Development

After the upgrade, the impacts on the community/community development should be positive. The positive impacts are long-term and direct through the potential for increased employment opportunities at Petrojam for persons living within the study area. This would increase incomes, which in turn would affect other economic activities such as shopping facilities for the population with increased residual incomes to spend on consumer goods. The skills set of the communities may increase if community members become involved in the accompanying skills training programme.

The upgrade should not affect the normal community activities in adjacent nearby communities.

Public Perception

The public perception (based on survey and other data described in Section 4.3.3.1) was generally very positive about the project although there were concerns about specific aspects (air pollution, hazardous waste) and in some cases indifference (proposed project would not affect them). The weighting assigned in the RIAM assessment assumed the project is permanent, irreversible and will have synergistic effects.

6.3.4 Macroeconomic Impacts After the Upgrade

The indicators for the macroeconomic component are:

- Energy Security
- Import costs/Foreign exchange
- Employment and Income
- Development of local industries

Energy Security

The existence of a viable oil refinery is important to enable diverse sources of energy supply to Jamaica i.e., both crude oil and finished products. Given the country's dependence on petroleum products for manufacturing, electricity generation, transportation and other vital areas of the economy, the upgrade will greatly diversify the sources of finished products. The upgrade will also allow the use of heavier lower cost crude oils thus adding flexibility (and hence security) in the sources of crude.

Import costs/Foreign exchange

The upgrade will eliminate the need to import higher cost gasoline and diesel since the increased capacity will allow conversion of heavy fuel oil into higher value products. The upgrade will also produce vacuum gas oil and diesel in excess of local demand and these will be exported – earning additional foreign exchange. The net foreign exchange savings were estimated at US $100 million but this estimate is uncertain in view of the fluctuations in prices of petroleum products.

Employment and Income

It is estimated that 35 additional engineers/supervisors and at least 150 additional skilled technical staff will be needed. There will also be increased demand for skilled and unskilled contract workers. The income earned has a multiplier effect since the income will be spent on goods and services in the local community and beyond.

Development of local industries

The upgrade will allow the production of Pet Coke and will also generate 18,725 tonne/y of sulphur.

The Pet Coke will be used by JPS in a 120 MW electricity generating station (about 10% of the total JPS generating capacity). Pet coke is less expensive on a $/BTU basis than heavy fuel oil and diesel which are currently used by JPS. The overall cost of electricity generation should therefore be reduced. The Pet coke electricity generating plant will require 110,00 tonne/y of limestone which will be supplied by local quarries. The electricity generation will also produce ash which can be used in road construction or as an additive for cement.

The sulphur by-product will be sold to the local sulphuric acid plant (~50% of the production) and the remainder could be exported. The use of locally produced sulphur will also reduce foreign exchange needed to import sulphur.

Other Cumulative Impacts

The production of low sulphur diesel for use in newer technology diesel engines as well as existing engines will reduce tailpipe emissions from these engines. The reduced emissions will have positive impacts on air quality and human health.

The improved wastewater treatment plant will allow Petrojam to meet and even exceed NEPA trade effluent standards. This will have a positive impact on the water quality in Kingston Harbour. The recent addition of the Soapberry Wastewater Treatment Plant, the Red Stripe wastewater treatment plant and the additional sewerage of industries along Spanish Town Road together should have a significant positive impact on water quality in Kingston Harbour.

The spatial scales of the import and energy security indicators are national in scale while employment and traffic are study area-specific. The positive impacts of the preferred alternative are assigned as permanent and synergistic since increased income and foreign exchange benefits will have multiplier effects in the communities and nationally.

6.4 QUANTITATIVE IMPACT ASSESSMENT BASED ON RIAM

Applications of the RIAM method described at the outset of this section (Section 6.1) are given for the “no action” alternative i.e., existing situation (Table 6-19), and for the preferred alternative during construction (Table 6-20) and during operation after the upgrade operation (Table 6-21).

Table 6-19 Summary of RIAM Assessment for the No Action (Existing Situation) Alternative

Environmental Component	No Action (Existing Situation) Alternative						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	A1	A2	B1	B2	B3	ES	RV
Physical and Chemical Components							
Hydrology (Ground and Surface water)							
Site Preparation	1	0	1	1	1	0	0
Demolition activities	1	0	1	1	1	0	0
Construction	1	0	1	1	1	0	0
Water abstraction	2	0	2	2	2	0	0
Spills, accidents & unplanned events	2	-1	2	2	2	-12	-2
Marine Vessel Accidents	2	0	2	2	2	0	0
(Maintenance)							
Repairs of tanks and pipelines	1	-1	2	2	2	-6	-1
Cleaning of tanks	1	-1	2	2	2	-6	-1
Storm Surge	1	-1	2	2	1	-5	-1
Marine Water Quality Impacts							
(Process Effluent)							
TEMP	1	0	2	2	2	0	0
TDS	2	-1	2	2	2	-12	-2
TSS	2	-1	2	2	2	-12	-2
O/G	2	-2	2	2	2	-24	-3
pH	2	0	2	2	2	0	0
Cr	2	0	2	2	2	0	0
S=	2	0	2	2	2	0	0
COD	2	-1	2	2	2	-12	-2
Phenols	2	-1	2	2	2	-12	-2
(Stormwater)							
TEMP	1	0	2	2	2	0	0
TDS	2	0	2	2	2	0	0
TSS	2	-1	2	2	2	-12	-2
O/G	2	0	2	2	2	0	0

Environmental Component	No Action (Existing Situation) Alternative						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	A1	A2	B1	B2	B3	ES	RV
pH	2	0	2	2	2	0	0
Cr	2	0	2	2	2	0	0
S=	2	0	2	2	2	0	0
COD	2	-1	2	2	2	-12	-2
Phenols	2	0	2	2	2	0	0
Storm Water Management	2	0	2	2	2	0	0
Gaseous emissions							
SO2	2	-1	2	2	3	-14	-2
NOx	2	-1	2	2	3	-14	-2
CO	2	0	2	2	2	0	0
TSP	1	0	2	2	3	0	0
VOC	2	-1	2	2	3	-14	-2
TRS	2	0	2	2	2	0	0
CO2	4	0	3	3	3	0	0
Occupational							
VOCs	1	-1	2	2	3	-7	-1
Dust	1	0	2	2	3	0	0
Noise	2	0	2	2	2	0	0
Solid Waste Management							
Site Waste management	1	0	2	2	2	0	0
Industrial Sludge	1	0	2	2	2	0	0
Spent Catalyst	1	0	2	2	2	0	0
Desiccant	1	0	2	2	2	0	0
Putrescible Solid Waste	1	0	2	2	2	0	0
Municipal Waste	1	-1	2	2	2	-6	-1
Metal Scrap	1	0	2	2	2	0	0
Biological and Ecological Component							
(Terrestrial)							
Impacts on biota & habitats	1	0	1	1	1	0	0
Terrestrial (Avifauna)	1	0	1	1	1	0	0

Environmental Component	**No Action (Existing Situation) Alternative**						
Activity/Discipline	**Spatial Importance (0-4)**	**Magnitude of change/effect (-3 to +3)**	**Permanence (1-3)**	**Reversibility (1-3)**	**Cumulative (1-3)**		
Parameter	A1	A2	B1	B2	B3	ES	RV
(Marine)							
Potential for Accidental releases	2	-1	2	2	3	-14	-2
Sociological and Cultural Components							
Land Use	1	0	1	3	1	0	0
Community Development	2	2	3	2	2	28	2
Public safety	2	-1	2	2	2	-12	-2
Human health	2	-1	2	2	2	-12	-2
Public perception	2	1	3	2	3	16	2
Economic and Operational components							
Employment and Income	2	1	2	2	3	14	2
Traffic (land)	2	0	2	2	2	0	0
Traffic (marine)	3	0	2	2	2	0	0
Import costs	3	-1	2	2	2	-18	-2
Energy Security	3	-1	2	2	2	-18	-2

Table 6-20 Summary of RIAM Assessment for the Preferred Alternative – During Construction

Environmental Component	During Construction						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	A1	A2	B1	B2	B3	ES	RV
Physical and Chemical Components							
Hydrology (Ground and Surface water)							
Site Preparation	1	-1	2	2	2	-6	-1
Demolition activities	1	-1	2	2	2	-6	-1
Construction	1	-1	2	2	2	-6	-1
Water abstraction	2	0	2	2	2	0	0
Spills, accidents & unplanned events	2	-2	2	2	2	-24	-3
Marine Vessel Accidents	2	-2	2	2	2	-24	-3
(Maintenance)							
Repairs of tanks and pipelines	1	-1	2	2	2	-6	-1
Cleaning of tanks	1	-1	2	2	2	-6	-1
Storm Surge	1	-1	2	2	1	-5	-1
Marine Water Quality Impacts							
(Process Effluent)							
TEMP	1	0	2	2	2	0	0
TDS	2	-1	2	2	2	-12	-2
TSS	2	-1	2	2	2	-12	-2
O/G	2	-2	2	2	2	-24	-3
pH	2	0	2	2	2	0	0
Cr	2	0	2	2	2	0	0
S=	2	0	2	2	2	0	0
COD	2	-1	2	2	2	-12	-2

Environmental Component	During Construction						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	**A1**	**A2**	**B1**	**B2**	**B3**	**ES**	**RV**
Phenols	2	-1	2	2	2	-12	-2
(Stormwater)							
TEMP	1	0	2	2	2	0	0
TDS	2	-1	2	2	2	-12	-2
TSS	2	-1	2	2	2	-12	-2
O/G	2	0	2	2	2	0	0
pH	2	0	2	2	2	0	0
Cr	2	0	2	2	2	0	0
S=	2	0	2	2	2	0	0
COD	2	-1	2	2	2	-12	-2
Phenols	2	0	2	2	2	0	0
Storm Water Management	2	0	2	2	2	0	0
Gaseous emissions							
SO_2	2	-1	2	2	3	-14	-2
NOx	2	-1	2	2	3	-14	-2
CO	2	0	2	2	2	0	0
TSP	1	0	2	2	3	0	0
VOC	2	-1	2	2	3	-14	-2
TRS	2	0	2	2	2	0	0
CO2	4	0	3	3	3	0	0
Occupational							
VOCs	1	-1	2	2	2	-6	-1
Dust	1	-2	2	2	2	-12	-2
Noise	2	0	2	2	2	0	0

Environmental Component	During Construction						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	A1	A2	B1	B2	B3	ES	RV
Solid Waste Management							
Site Waste management	1	-1	2	2	2	-6	-1
Industrial Sludge	1	-1	2	2	2	-6	-1
Spent Catalyst	1	-1	2	2	2	-6	-1
Desiccant	1	0	2	2	2	0	0
Putrescible Solid Waste	1	0	2	2	2	0	0
Municipal Waste	2	-1	2	2	2	-12	-2
Metal Scrap	1	0	2	2	2	0	0
Biological and Ecological Component							
(Terrestrial)							
Impacts on biota & habitats	1	0	1	1	2	0	0
Terrestrial (Avifauna)	1	0	1	1	2	0	0
(Marine)							
Potential for Accidental releases	2	-1	2	2	3	-14	-2
Socioeconomic and Cultural Component							
Land Use	1	0	2	2	1	0	0
Community Development	2	3	2	2	2	36	3
Public safety	2	-1	2	2	2	-12	-2
Human health	2	-1	2	2	2	-12	-2
Public perception	2	3	3	2	3	48	3
Macroeconomic Component							
Employment and Income	2	2	2	2	2	24	2
Traffic (land)	2	-1	2	2	2	-12	-2
Traffic (marine)	3	-1	2	2	2	-18	-2

Environmental Component		**During Construction**						
	Activity/Discipline	**Spatial Importance (0-4)**	**Magnitude of change/effect (-3 to +3)**	**Permanence (1-3)**	**Reversibility (1-3)**	**Cumulative (1-3)**		
	Parameter	**A1**	**A2**	**B1**	**B2**	**B3**	**ES**	**RV**
	Import costs	3	1	2	2	2	18	2
	Energy Security	3	1	2	2	2	18	2

Table 6-21 Summary of RIAM Assessment for the Preferred Alternative – After the Upgrade

Environmental Component	After the Upgrade						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	A1	A2	B1	B2	B3	ES	RV
Physical and Chemical Components							
Hydrology (Ground and Surface water)							
Site Preparation	1	0	1	1	1	0	0
Demolition activities	1	0	1	1	1	0	0
Construction	1	0	1	1	1	0	0
Water abstraction	2	0	2	2	3	0	0
Spills, accidents & unplanned events	2	-1	2	2	2	-12	-2
Marine Vessel Accidents	2	-1	2	2	2	-12	-2
(Maintenance)							0
Repairs of tanks and pipelines	1	-2	2	2	2	-12	-2
Cleaning of tanks	1	-2	2	2	2	-12	-2
Storm Surge	1	-1	2	2	1	-5	-1
Marine Water Quality Impacts							
(Process Effluent)							
TEMP	1	0	2	2	2	0	0
TDS	2	0	2	2	2	0	0
TSS	2	0	2	2	2	0	0
O/G	2	0	2	2	2	0	0
pH	2	0	2	2	2	0	0
Cr	2	0	2	2	2	0	0
S=	2	0	2	2	2	0	0
COD	2	0	2	2	2	0	0

Environmental Component	After the Upgrade						
Activity/Discipline	**Spatial Importance (0-4)**	**Magnitude of change/effect (-3 to +3)**	**Permanence (1-3)**	**Reversibility (1-3)**	**Cumulative (1-3)**		
Parameter	**A1**	**A2**	**B1**	**B2**	**B3**	**ES**	**RV**
Phenols	2	0	2	2	2	0	0
(Storm water)							
TEMP	1	0	2	2	2	0	0
TDS	2	0	2	2	2	0	0
TSS	2	0	2	2	2	0	0
O/G	2	0	2	2	2	0	0
pH	2	0	2	2	2	0	0
Cr	2	0	2	2	2	0	0
S=	2	0	2	2	2	0	0
COD	2	0	2	2	2	0	0
Phenols	2	0	2	2	2	0	0
Storm Water Management	2	0	2	2	2	0	0
Gaseous emissions							
SO_2	2	-1	2	2	2	-12	-2
NOx	2	-1	2	2	3	-14	-2
CO	2	0	2	2	2	0	0
TSP	1	0	2	2	3	0	0
VOC	2	-1	2	2	3	-14	-2
TRS	2	-1	2	2	2	-12	-2
CO2	4	0	3	3	3	0	0
Occupational							
VOCs	1	-1	3	2	3	-8	-1
Dust	1	0	3	2	3	0	0
Noise	2	0	3	2	2	0	0

Environmental Component	After the Upgrade						
Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
Parameter	**A1**	**A2**	**B1**	**B2**	**B3**	**ES**	**RV**
Solid Waste Management							
Site Waste management	1	0	2	2	2	0	0
Industrial Sludge	1	0	2	2	2	0	0
Spent Catalyst	1	0	2	2	2	0	0
Desiccant	1	0	2	2	2	0	0
Putrescible Solid Waste	1	0	2	2	2	0	0
Municipal Waste	1	-1	2	2	2	-6	-1
Metal Scrap	1	0	2	2	2	0	0
Biological and Ecological Component							
(Terrestrial)							
Impacts on biota & habitats	1	0	1	2	2	0	0
Terrestrial (Avifauna)	1	0	1	2	2	0	0
(Marine)							
Potential for Accidental releases	2	-2	2	2	3	-28	-3
Socioeconomic and Cultural Component							
Land Use	1	0	3	3	1	0	0
Community Development	2	3	3	3	3	54	3
Public safety	2	-1	2	2	2	-12	-2
Human health	2					0	0
Public perception	2	3	3	3	3	54	3
Macroeconomic Component							
Employment and Income	2	2	2	2	3	28	2
Traffic (land)	3	0	2	2	2	0	0
Traffic (marine)	3	-1	2	2	2	-18	-2

Environmental Component		After the Upgrade						
	Activity/Discipline	Spatial Importance (0-4)	Magnitude of change/effect (-3 to +3)	Permanence (1-3)	Reversibility (1-3)	Cumulative (1-3)		
	Parameter	**A1**	**A2**	**B1**	**B2**	**B3**	**ES**	**RV**
	Import costs	3	2	2	2	3	42	3
	Energy Security	3	2	2	2	3	42	3

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7 MITIGATION AND MONITORING

7.1 MITIGATION

The mitigation measures described here will address the periods during construction and after the upgrade. Where measures are specific to one period only they will be so identified.

7.1.1 Mitigation – Physical and Chemical Impacts

7.1.1.1 Mitigation of Seismic and Hurricane Impacts

The seismic hazard assessment noted that the site is in an area that can expect significant peak ground acceleration in an earthquake. Jamaica's National Building Code published in 1983 is undergoing revision and a draft prepared in 1993 included structural design standards for earthquake loads. The latest draft for seismic design criteria specifies an expected peak acceleration of 40% g with a 10% probability of exceedance in 50 years for Kingston (Caribbean Disaster Mitigation Project, 2001). In view of the refinery's key role in Jamaica's economy and the disruption that would occur in the event of damage due to an earthquake Petrojam has proposed seismic design criteria of 40%g consistent with the proposed draft of the building code for a high risk earthquake area. [This is equivalent to an earthquake intensity VII on the Modified Mercani Intensity Index measure.]

The site is also subject to hurricanes. The design of the structures for the upgrade will include the ability to withstand 3 second wind gusts of 155 mile/hr. [Note that the lowest end of a Category 5 hurricane on the Saffir-Simpson scale is 155 miles/hour. The scale is based on a 1-minute average.]

7.1.1.2 Air Quality Mitigation

Mitigation of air quality impacts during construction will focus on reducing dust generating activities. These measures will include dust suppression by wetting unpaved areas, cleaning of paved roadways and if necessary wetting.

Since the refinery will be in operation during construction, the ambient monitoring in connection with the air quality licence will continue during construction as well as after the upgrade. The ambient monitoring (see below) will consist of continuous (hourly average) measurements for SO_2, NO, NO_2 and meteorological parameters [wind speed & direction, temperature] and daily average PM_{10} at three stations and hourly average TRS at one station. Until these ambient monitoring data are available (especially for SO_2 which is the pollutant predicted by the model to exceed the JNAAQS) no mitigation of gaseous emissions will be contemplated. This is because the model is known to over-predict especially for short term (1 h and 24 h) averaging periods.

7.1.1.3 Occupational Exposure Mitigation

Occupational exposure to noise, dust and fumes during construction and after the upgrade will be mitigated by sequencing noisy activities so they occur during the same time period, avoiding night-time activities and maintaining adherence to the wearing of protective hearing devices and breathing devices and also adherence to good housekeeping practices. The latter relate to the storage and disposal of unwanted hydrocarbon streams from maintenance activities and cleanup from spills. During construction the use of quieter demolition methods and equipment with silencers or constructing temporary barriers around stationary noise sources such as generators and compressors.

7.1.1.4 Mitigation of Vibration Impacts

Vibration Mitigation During Construction

Measures to mitigate of vibration can addressed at the source, the transmission path or at the receiver. Source control methods include the use an augur to install piles instead of a pile driver: this would greatly reduce the noise and vibration levels. Piles in properly selected patterns also reduce transmitted vibrations. Introducing barriers to the vibration waves in the transmission path can reduce vibrations that reach a building. When surface waves predominate, deep trenching (which may be backfilled with bentonite) is an effective method. Other methods are to avoid demolition methods that involve impact, avoid the use of earth-moving equipment, vibratory rollers and packers near sensitive areas.

Because the mitigation of construction vibration is very difficult, the most common mitigation measure is to phase and limit the times when pile driving and other vibration inducing activities can occur. This can be achieved by sequencing demolition, earth moving and ground-impacting operations so they do not occur at the same time. Since persons at home are more aware of vibration at night, night-time activities should be avoided.

The processing area for the upgrade is located near the centre of the property and is at least 150 m from the fence line along Marcus Garvey Drive to the north and over 180 m from the property line to the west (adjacent to the fishing village). Any pile driving for construction associated with the processing area for example for foundations to tall stacks and other structures (columns) are not likely to affect adjacent properties.

The upgrade will also include the relocation of four storage tanks and the construction of new buildings that are located closer to Marcus Garvey Drive. These activities are not expected to require pile driving. In addition, it is recommended that Petrojam conduct a pre-construction survey of buildings within 100 m of where pile driving will take place – even though effects are typically not found beyond 30 m. In assessing potential impacts of adjacent structures, their natural frequencies will be estimated and compared with anticipated characteristics of pile driving and other vibratory construction equipment to anticipate potential for structural damage and recommend action to be taken to avoid such damage. Based on the survey the need for monitoring vibration during construction will be evaluated.

During the installation of equipment that is prone to creating vibration, it is recommended that equipment manufacturers' specifications for isolation of equipment (e.g., by springs, spring-like pads or locating equipment where it is less prone to transmitting vibrations) be followed.

Vibration Mitigation After the Upgrade

After the upgrade it is recommended that routine maintenance procedures be put in place to ensure vibration is minimised. These measures include inspection and maintenance of mountings used to isolate machinery that is prone to vibrations and the balancing or reciprocating and rotating machinery.

7.1.1.5 Mitigation - Surface and Groundwater Impacts

During demolition/construction measures should be put in place to ensure the following:

- All temporary fuel, oil and chemical storage are sited on an impervious base within a bund and secured. The base and bund walls must be impermeable to the material stored and of an adequate capacity.
- All waste streams will be removed from the site immediately and disposed of via a licensed waste disposal contractor or in conjunction with the local authority.
- All tanks are properly de-sludged and the sludge appropriately contained in watertight containers and treated prior to disposal.
- Washings from concrete mixers, paint or paint utensils should not be allowed to flow into any drain or watercourse.
- Erosion control systems should be established to manage runoff from the construction area, minimizing the amount of runoff that occurs.

Generic measures to minimize sedimentation and erosion potential include:

- construction sequencing to minimize soil exposure;
- retaining existing drainage routes as long as possible;
- diverting runoff from the denuded areas;
- intercepting sediments on site;
- inspecting and maintaining control measures;
- erosion control fencing; and s
- sedimentation control ponds.

Preliminary investigation of the aquifer for locating the (three) abstraction wells should ensure that after completion these wells are appropriately plugged to close the direct migration pathway to the aquifer created by the exploratory wells. This can be done by grouting the wells with low permeability bentonite grout from base to ground level to ensure no gaps with the wells.

The installation of three abstracting wells will be used to provide process water. Pumping from a well causes a lowering of the water table, typically in the form of a cone emanating from the well, called the cone of depression. The size and shape of the cone of depression depends on a number of factors, including pumping rate and the hydrogeological characteristics of the aquifer in which the well is located. A pump test will be completed to determine the extent of the drawdown and there will be ongoing monitoring and reporting to WRA of abstraction rates.

Sewage generated during demolition and construction will be handled by the existing septic management system and there should be no impact on the aqueous environment.

Since the RUP processing area is located in areas where there is potential for subsurface hydrocarbon contamination the mitigation measures must be based on an assessment of the nature and extent of the subsurface contamination and the amount of material that would be excavated.

The first step would be for Petrojam to assess the extent of contamination in areas to be excavated. A critical aspect of the assessment and mitigation will be the establishment of acceptable soils quality (soil quality guidelines or standards) for an industrial site (industrial land use). NEPA does not have sampling and analytical protocols or soil quality guidelines for the assessment or cleanup of contaminated sites and hence we recommend adapting guidelines in other jurisdictions that are relevant to petroleum hydrocarbon contamination.

Assessment

The sampling plan designs can vary depending on the expected spatial distribution of the contaminants but in the current situation a systematic sampling plan (i.e., sampling locations on a regular grid) is recommended. A detailed sampling protocol would be prepared in which the sampling plan, sampling and analytical methods for soil and groundwater and assessment methodologies (including proposed criteria or guideline levels for contaminants based on standards or guidelines in other jurisdictions) would be specified.

If the assessment indicates that the contaminant levels are unacceptable for an industrial site then a decision would be made to either a) cleanup or remediation the contaminated soil, b) allow the contaminated soil to be left in place (i.e., burying excavated soil and removing or remediating surplus soil). Several remediation methods are available (e.g., landfarming or biopiles) and have proven to be effective in treating soil contaminated with petroleum products. Landfarming has been used in Jamaica at several petroleum retail sites with above-average results. Remediation goals of both systems, if appropriately designed and managed by contamination remediation professionals, can lead to 95% reduction in petroleum-based compounds to concentrations of about 1 ppm within 6-12 months. If the contaminated soils to be excavated are shallow (i.e. less than 1m below ground), it may also be possible to stimulate microbial activity through land farming without excavating the soils. For deeper soils the soils can be excavated, treated as above, and re-instated.

Mitigation:

The following measures can be used to reduce the occupational exposure during excavation:

- training workers in the methods for safely handling contaminated soils including containment methods and the use of personal protective equipment to eliminate skin contact and inhalation
- management of excavated piles to suppress dust, avoid contact with rainwater and eliminate entrainment of particles by wind

These measures will be sufficient to eliminate occupational exposure pathways (skin contact and inhalation) and mobilization into ground water and air therefore eliminating the potential occupational, ecological and human health impacts.

7.1.2 Mitigation – Biological Impacts

Further significant impact to terrestrial or marine ecosystems is not anticipated from normal activities anticipated within this development scenario. As a worst case scenario, impacts resulting from this development should not have any more negative impact than those already possible.

7.1.2.1 Terrestrial

The habitat is already highly degraded and not considered of significance for feeding, nesting or roosting activities of terrestrial species. Mitigation should therefore seek to prevent additional impact or reduce existing impact to this area. The following measures are recommended:

- Continue the regular clearing of drainage ditches to lessen the impact of pest nuisances or water pooling onsite
- Continue programs for handling waste and hazardous materials (including any new hazardous materials) and emergency management

7.1.2.2 Marine

The marine environment can potentially be affected by impacts from runoff and spills (addressed elsewhere).

Protocols for maintenance activities associated with cleaning of tanks will be revised to ensure that sandy/sediment containing wash water is collected so that the sediment/sandy material is allowed to settle before treatment and discharge of the supernatant. The sediment/sandy material will be disposed of in a landfill or other suitable/approved method.

7.1.3 Mitigation - Socioeconomic Impacts

Mitigation measures for the socio-economic impacts are described below and are summarized in the Rapid Impact Assessment Matrix (RIAM). Mitigative measures are recommended to off-set the negative impacts of the proposed development.

7.1.3.1 Employment

Petrojam has estimated that approximately 1,200 to 2000 skilled jobs will be required during the construction phase of the project. The required skills include welders, mechanics, pipe-fitters and general construction workers. However, the socioeconomic and perception survey results indicated that the communities surrounding the proposed project site have low levels of skill sets which may reduce benefits to them. In order to compensate for these deficiencies a skills training initiative will be required.

In order to maximize the benefits of the proposed project to communities surrounding the study site, Petrojam in collaboration with HEART Trust NTA, is in the process of developing a skills training programme for community members. Based on information obtained from Petrojam, the number of participants will not be limited to the number of workers required, which will have more far reaching benefits to the communities since successful (certified) trainees who do not obtain employment at Petrojam will have the skills and hence potential to obtain employment elsewhere.

Community members/groups and organizations who are aware of the proposed project should mobilize themselves to encourage unemployed, uncertified skilled persons and unskilled persons to take advantage of opportunities presented by the proposed project. Those who can afford it should get trained and certified, while others should make every effort to participate in the proposed training programme being developed by Petrojam and Heart Trust.

The participatory approach to the proposed project has provided additional opportunities for partnerships to be developed and/or enhanced to facilitate development of the communities within the study area.

7.1.3.2 Communication

In section 4.1.9 it was noted that at the public meeting a need was identified for improvement in the communication/warnings to nearby residents during emergencies and participation in emergency response planning.

To address this, we recommend that the existing Terms of Reference of the Community Outreach Committee be modified to include the communication with the community about emergency response plans and that Petrojam establish protocols for notification/warnings of nearby communities and for their involvement in emergency response and evacuation plans as may be appropriate. Participation of the communities could take the form of a Public Education Programme directed at emergency response and appropriate community involvement in drills etc.

7.1.3.3 Transportation

There may be disruptions to the smooth flow of traffic during construction as a result of moving large equipment on site. Despite the special arrangements (scheduling such activity at night or low traffic periods - e.g., week-ends) usually adopted for such activities by Petrojam in conjunction with the police, KSAC, NWA, JPS, etc., it is recommended that notice of such activity that may impact communities and commuters be communicated in a timely manner. Where feasible the movement of large items from the wharf to the site by barge will mitigate disruption of traffic if those items were moved by road.

7.2 SUMMARY OF QUANTITATIVE IMPACT ASSESSMENT

Quantitative assessment of the impacts in all study disciplines was assessed for the current situation, during construction and after the upgrade using the rapid impact assessment matrix (RIAM) method. The RIAM method assigns numerical scores to each impact depending on whether or not the impact A) can be quantified because of the area over which the effect takes place or the magnitude of the effect or B) is permanent, reversible or cumulative on the one hand. The impacts in A are assigned numerical scores of 0 to 4 for the spatial importance, -3 to +3 for the magnitude; the scores for the B are 1 (no change), 2 (temporary, reversible or non-cumulative) or 3 (permanent, irreversible or cumulative/synergistic). The scores for the “A” effects are multiplied together while those for the “B” effects are added. An overall score is obtained by multiplying the result for the A and B scores.

The process can be expressed as follows.

(a1)x(a2) =aT

(b1)+(b2)+(b3) = bT

(aT)x(bT) = ES

Where

(a1) and (a2) are the individual criteria scores for group (A)

(b1) to (b3) are the individual criteria scores for group (B)

aT is the result of multiplication of all (A) scores

bT is the result of summation of all (B) scores

ES is the assessment score for the condition.

The overall assessments for the three scenarios (Existing, during construction and after the upgrade) are presented in Table 7-1. The assessment shows that the most positive impacts are from the sociological and economic aspects (the environmental score (ES) or range value (RV) are more positive than the existing situation); there is no significant change in terrestrial or physical impacts but there is deterioration in the marine aspect. The negative impacts for marine impacts are due to the increased marine traffic and the greater potential for marine accidents. These point to a need for greater vigilance in preventive measures for shipping (loading/unloading of raw materials (crude) and products or intermediates that are shipped.

7.3 ENVIRONMENTAL MANAGEMENT AND MONITORING

Petrojam has developed and documented a formal environmental a management system and an Industrial hygiene program. The key features of these are shown in the text boxes on the pages following Table 7-1.

Table 7-1 Summary of Quantitative Impact Assessment

Activity/Discipline	**Existing**		**During Construction**		**After the Upgrade**	
Parameter	**ES**	**RV**	**ES**	**RV**	**ES**	**RV**
Physical and Chemical Components	***-174***	***-5***	***-251***	***-5***	***-113***	***-5***
Hydrology (Ground and Surface water)	-24	-3	-78	-5	-48	-4
Storm Surge	-5	-1	-5	-1	-5	-1
Marine Water Quality Impacts	-96	-5	-108	-5	0	0
Gaseous emissions	-42	-4	-42	-4	-52	-4
Occupational	-7	-1	-18	-2	-8	-1
Noise	0	0	0	0	0	0
Solid Waste Management	-6	-1	-30	-3	-6	-1
Biological and Ecological Component	***-14***	***-2***	***-14***	***-2***	***-28***	***-3***
Terrestrial	0	0	0	0	0	0
Marine	-14	-2	-14	-2	-28	-3
Sociological and Cultural Components	***20***	***2***	***60***	***3***	***96***	***4***
Economic and Operational components	***-22***	***-3***	***30***	***2***	***94***	***4***

Key Features of Petrojam's Environmental Management System

1.0 Purpose Scope and Objectives

1.1 Purpose

To establish a programme to ensure that sound environmental practices are adhered to, as stipulated by all applicable local and international standards and guidelines.

1.2 Scope

This policy applies to all Petrojam Permanent, Temporary, Casual and Contracted Employees at all Petrojam's operated facilities.

1.3 Objectives

The main objectives of this document include the following:

- To set instructions for identifying environmental aspects and impacts of Petrojam's activities with a view to determining the significant impacts on the environment
- To establish a system to identify environmental legal requirements
- To establish procedures to monitor and measure key characteristics of the refinery and activities that can have a significant impact
- To establish and document the environmental objectives and targets
- To define the roles and responsibilities that will facilitate effective environmental management
- To establish an environmental management programme

2.0 Petrojam Environmental Policy

The management of Petrojam is committed to our goal of refining crude oil into its various petroleum products while giving due consideration of sound environmental management guidelines and strict adherence to safe work practices. Within this framework we shall endeavor to:

- Comply with all applicable local laws (NRCA Act 1991, Public Health Act 1972, Factories Act 1943, Petroleum Quality Control Act 1991 etc),
- Employs petroleum industry best practices for prevention of pollution as outlined in the rest of Petrojam's HSEM Guideline document (Based on OSHA 29 CFR 1910.119)
- Establish and maintain environmental objectives and targets through continuous evaluation of environmental aspects and impacts
- Continuously seeking the input of employees and other stakeholders in establishing and maintaining the EMS in a current and relevant state as well as communicating the requirements, objectives and achievements of the EMS to them

Key Features of Petrojam's Industrial Hygiene Program

1.0 Purpose, Scope, and objectives

1.1 Purpose

To es tablish procedures that w ill gui de the pr ocess of ens uring t hat s ound industrial hygiene practices are adhered to, or supercedes those as stipulated by all applicable local and international standards and guidelines.

1.2 Scope

This policy applies to all Petrojam Permanent, Temporary, Casual and Contracted Employees at all Petrojam's operated facilities.

1.3 Objectives

The main objectives of this document include the following:

- To es tablish and document the i ndustrial hy giene practices, obj ectives and targets. To establish an industrial hygiene programme
- To identify local industrial hygiene legal requirements as well as industry best practice.
- To s et the policy fr amework and activities for anti cipating, r ecognizing and evaluating IH haz ards i n P etrojam ac tivities, with a v iew to c ontrolling or eliminating them.
- To defi ne the roles and responsibilities of w orkers that w ill fac ilitate e ffective industrial hygiene management.
- To es tablish pr ocedures to m onitor and m easure k ey c haracteristics of the refinery activities that can have an impact on worker health and safety.

2.0 Petrojam Industrial hygiene Policy

The management of Petrojam is committed to our goal of refining crude oil into its various component products w hile gi ving due c onsideration for sound industrial hygiene practices. Within this framework we shall endeavor to:

- Comply with all applicable laws, standards, regulations and industry codes of practice
- Employ best practice in industrial hygiene
- Establish industrial objectives and targets through consultative process utilizing employee participation, management review on Industrial Hygiene aspects and impacts.
- Prevent workplace related illness or injury to all employees and contractors.
- Promote the i mportance of oc cupational health and s afety in all aspects and operations of the refinery
- Communicate this policy to all stakeholders including employees and the public.
- Continuously seek opportunities to improve the effec tiveness of the I ndustrial Hygiene management of our operations.

The monitoring programme is designed to ensure that the requirements of the Licences and Permits granted by the NEPA are met and to verify that negative or residual impacts are mitigated.

Monitoring and mitigation of impacts during the implementation of the project will also require co-ordinated scheduling of activities between Petrojam and the consultants, as well as regular reports required by the NEPA. As required by the TOR for EIA an outline of the monitoring program and Petrojam's environmental management system are provided in the Appendix (Section 9.7).

Air quality, environmental water chemistry and ecological parameters that may be affected by construction and operation of the development will be monitored with the necessary fieldwork component to provide the data as needed.

Field observations and measurements will be correlated simultaneously with weather prevailing conditions, so that any change in weather can be compensated for. In order to abide by the terms of the Licence and the Permit set by the authorities, and certify satisfactory completion of the project, it will be necessary to perform the following:

The monitoring of ambient air quality parameters will entail the establishment of air monitoring station in cooperation with the nearby Jamaica Public Service Company (JPS) Hunts Bay electricity generating station. The monitoring program will entail establishment of three permanent ambient stations that will measure hourly average concentrations of SO_2, NO, NO_2, NOx and meteorological parameters (wind speed, wind direction, temperature, relative humidity) and daily average PM_{10} concentrations every sixth day at all three stations and hourly averaged total reduced sulphur (TRS) concentration at one of the three stations. The locations of the stations will be at the "Boat House" site adjacent to the Petrojam fence line at the south-western corner of the property, the Garmex Heart Institute site and a site in Newport West.

During construction, additional ambient monitoring of PM_{10} or TSP will be conducted at two locations on the property. The monitoring schedule will be based on construction and demolitions activities likely to generate dust and will be based on monitoring every third day.

The ongoing occupational monitoring for total hydrocarbons and total reduced sulphur will be continued at four locations within the property using Drager tube (grab) sampling.

Based on the health risk assessment, it is recommended that these measurements be complemented with two surveys using passive monitoring – one during construction and the other three months after start-up of the upgraded project. The survey would be of one month duration and entail 8 or 12 hour exposures at six sites and 48 hour exposures at six (6) sites [the same sites used during the EIA]. The data will be reviewed to determine the need for additional passive VOC monitoring.

Occupational noise monitoring will be made during construction at three perimeter locations and in the vicinities of where noise generating activities take place.

The ongoing monitoring of water quality parameters at the existing API separator and storm drain outfalls during construction and after the upgrade will be continued and upgraded. It is recommended that devices to measure the flow rates for all drains and to take composite samples be installed as soon as possible. Once the new waste water plant is constructed similar outfall locations will be monitored. The parameters monitored will be Total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen (DO), conductivity, oil and grease, sulphide, pH, chemical oxygen demand (COD) and phenol. Samples will be collected every other day using composite sampling (instead of the current grab sampling) once equipment is procured. The sampling frequency will be adjusted if necessary based on a review of the first six months data.

It is recommended that marine and ecological observations be introduced to observe any changes in the marine water quality and the composition of marine, (benthic, pelagic) species. Marine water quality would be conducted near the outfalls once per month while three sets of ecological monitoring would be conducted (at the start and quarterly until the end of construction). Monitoring will be carried out more frequently if the results of initial and after the first quarter monitoring suggest that there are potential changes in the marine or ecological parameters. Once construction is completed the frequency of monitoring would be adjusted.

A summary of the mitigation measures (with preliminary cost estimates where feasible) is given ion Table 7-2.

OUTPUT/REPORTING

The information from the monitoring exercise will be used to guide Petrojam and NEPA regarding the efficacy of the mitigation measures and of pollution control equipment. Any changes required to enhance the effectiveness of existing mitigation actions would then be recommended. Quarterly monitoring reports will contain the results of all monitoring, any photographic or other observations that are made in the reporting period, and recommendations for action, if required, for improving the construction process from an environmental perspective or to adjust the frequency of monitoring. Data will be presented in both tabular and where appropriate graphic forms. The monitoring plan will include criteria for adjustment of the monitoring frequency.

Table 7-2 Estimate of Mitigation Costs

IMPACTS	MITIGATION	ESTIMATED COSTS
Seismic and hurricane Impacts	• Designs for Category 5 Hurricanes and to Earthquake High Risk standards	• Included in design for upgrade. No separate cost available.
Air quality impacts	• Dust suppression (watering, covering storage piles) • Ambient AQ monitoring (Note cost of 1 station including PM_{10} , NO_2, SO_2, TRS, wind speed, wind direction, temperature and rainfall)	• J$30,000/year • Capital (US $170,000) Operational (US$8,000/year)
Occupational exposure impacts	• Sequencing of noisy activities, avoiding night time activities. • Provision of temporary noise suppression barriers if needed	• Nominal additional cost • ~J$10,000/barrier
Vibration impacts	• Phasing and limiting times of pile driving and sequencing of activities. • Post-construction inspection and maintenance of mounts used to isolate vibration prone machinery	• Nominal additional cost • (Assume 1 person-day/month or J$7000/month)
Surface and groundwater impacts	• Waste stream management • Management of storage of fuel oils and tank safety	• Included in design of wastewater treatment plant (WWTP US $5.29 Million) • No additional cost – included in normal operations
Impacts due to establishment of new wells	• Pump tests to minimise coning. Note: pump testing is typically included in establishment of wells	• Estimated at J$5 million per well (i.e. , includes drilling and pump testing)
Impacts due to soil contamination	• Assessment of potentially contaminated areas • Soil remediation (as and if needed)	• Estimated at US $15,000 • Estimate will depend on extent of contamination
Terrestrial (biological) impacts	• Regular cleaning of drainage ditches • Hazardous materials management.	• No additional cost – included in normal operations • No additional cost – included in normal operations
Marine impacts	• Runoff and sediment management	• No additional cost – included in normal operations
Socioeconomic impacts	• Skills training to access employment during and after construction • Improved community engagement • Traffic management during construction	• Training estimated at J$79 million • Nominal additional effort • Nominal additional cost

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9 APPENDICES

9.1 EIA TERMS OF REFERENCE

TERMS OF REFERENCE FOR AN ENVIRONMENTAL IMPACT ASSESSMENT

Submitted by PETROJAM Ltd Refinery Upgrade Project.

Project Brief

The Petrojam Limited refinery is being upgraded from a simple hydroskimming plant to a conversion facility. The purpose of the upgrade is to expand the refinery capacity from 35,000 to 50,000 barrels per day and to convert Heavy Fuel Oil (HFO) into more valuable light products through the use of mature proven technology. The upgraded refinery will see the addition of the following main process units and key waste treatment facilities for both liquid and gaseous effluents.

Existing Units Being Upgraded
- Crude Distillation Unit
- Gas Recovery Unit
- Kerosene Hydrotreater
- Main New Process Units
- Distillate Hydrotreater
- Naphtha Hydrotreater
- Continuous Catalyst Regeneration Platformer Unit
- Vacuum Unit
- Delayed Coking Unit

New Effluent Treatment Units
- Sour Water Stripper
- Amine Absorber
- Sulphur Recovery Unit
- Tail Gas Treatment Unit
- Waste Water Treatment Plant

Crude from storage tanks will be passed through the existing Desalter for salt and solids removal, then pre-heated in a set of heat exchangers and then finally to the desired temperature in a fuel oil fired furnace (as is currently the case) before entering the upgraded Crude Distillation Unit (CDU). There will be five streams from the CDU: liquefied petroleum gas (LPG), naphtha, kerosene, distillate and fuel oil.

LPG

LPG and naphtha from the CDU will be fed to the Gas Recovery Unit (GRU). The GRU will consist of a series of heat exchangers and distillation towers where the naphtha is separated from the LPG and routed to the Naphtha Hydrotreater. Gases lighter than propane will subsequently be removed from the LPG and routed to the fuel gas system after H_2S is removed in the Amine Absorber. LPG (i.e., propane and butane) are separated from each other and sent to their respective storage facilities.

Naphtha (Gasoline Precursor)

Hydrogen-rich treat gas is added to the naphtha from the GRU and the combined stream heated in a pre-heat exchanger then in a fuel gas fired heater. The heated naphtha-hydrogen stream will then be fed to a new Naphtha Hydrotreater (NHT) for sulphur removal.

Hydrotreated naphtha will be fed to a Naphtha Splitter where light sour gases will be removed. Additionally, light virgin naphtha (LVN) will be separated from feed to the Continuous Catalyst Regeneration (CCR) Platformer and sent to tanks for gasoline blending.

In the CCR, naphtha will be upgraded to gasoline in a series of fuel gas fired heaters and catalytic reactors. Chlorides (in the form of perchloroethylene, PCE) will be added continuously to the reactor feed to ensure optimum catalyst activity. Hydrogen will be produced during the reforming reactions, some of which will be recycled to the CCR. The rest of the hydrogen will be compressed and sent to the Naphtha and Distillate Hydrotreaters. The gasoline product will be stripped of light gases in a distillation column then sent to tankage for blending. The stripped gases will combine with other gases to the Amine Absorber.

The key feature of the CCR is the continuous regeneration of the catalyst, whereby coke deposits are burnt off. Chlorides are inevitably released from the catalyst during regeneration and are present in the vent gas as hydrochloric acid (HCl). There are two main options for HCl removal from vent gases: caustic scrubbing or use of an absorption system (Chlorsorb®). The Chlorsorb® method was chosen as it eliminates the use of caustic and hence the need to dispose of spent caustic. The Chlorsorb system is thus the environmentally friendly solution for reducing chloride emissions from a CCR Platforming unit. There is virtually no waste associated with the use of Chlorsorb®.

Note that there is also the option to add unhydrotreated naphtha from storage to the NHT, and also to add hydrotreated naphtha from storage to the CCR.

Kerosene

As with the existing refinery, kerosene from the CDU will be combined with hydrogen treat gas then fed directly to the Kerosene Hydrotreater (KHT) for sulphur removal. Hydrotreated kerosene will then enter a Kerosene Stripper where light gases (hydrocarbons, H_2S, H_2) will be removed and sent to the fuel gas system after sulphur recovery. The kerosene product will then be sent to tanks for blending. Note the light gases are burnt as fuel and are not released to the atmosphere.

Distillate

Downstream processing of distillate is similar to that of kerosene. Distillate from the CDU and Delayed Coking Unit (DCU) will be combined with hydrogen-rich treat gas then heated in a new fuel gas fired furnace and fed to a new Distillate Hydrotreater (DHT). Hydrotreated distillate (diesel) will then be fed to a Diesel Stripper for removal of light gases (hydrocarbons, H_2S, H_2) and sent to the fuel gas system. The diesel product will then be sent to tanks for storage and blending, while the naphtha removed will be routed to the NHT along with the naphtha from the GRU.

Fuel Oil

Fuel oil from the CDU will be split into two streams: one will be routed to the existing Asphalt Unit for asphalt production via the existing fuel gas fired heater; the other will be fed via a new fuel oil fired heater to a new Vacuum Unit and separated into atmospheric gas oil (AGO), vacuum gas oil (VGO) and vacuum tower bottoms. AGO will be combined with the diesel feed to the Diesel Hydrotreater while VGO will be sent directly to storage tanks.

Vacuum Tower Bottoms

Vacuum tower bottoms (VTB) will be fed to a Delayed Coking Unit (DCU) via a fuel gas fired heater. In the DCU, the VTB is converted into lighter, more valuable products, namely LPG, naphtha, distillate and gas oil; products similar to those produced in the CDU. The residual petroleum coke (petcoke) will be sold as a by-product, which can be used to generate electricity in a similar fashion to coal.

Gases lighter than LPG which are produced in the DCU will be routed to the refinery fuel gas system along with those from the main GRU.

The LPG will be routed through a separate Gas Recovery Unit dedicated to DCU LPG, then to their respective storage vessels.

The naphtha and distillate will be combined with the feed to the DHT.

The coker gas oil (CGO) will be blended with the VGO and routed to storage.

The petcoke will be stored in stockpiles.

Sulphur Recovery

All light hydrocarbon gases destined for the fuel gas system will first be passed through an Amine Absorber in which an aqueous solution of Methyl Diethanol Amine (MDEA) will be used to absorb H_2S, CO_2 and mercaptans from the gases. Consequently SO_2 emissions from fired heaters will be substantially reduced. The MDEA, rich in acid gas, will then be fed to an Amine Regenerator (distillation tower) where the acid gases will be removed from the MDEA stream. The resultant acid gas (rich with H_2S) will be routed to the Sulphur Recovery Unit (SRU), while the MDEA will be recycled to the Amine Absorber.

Sour water streams (water with high H_2S and ammonia content) will be collected in a tank and fed to a Sour Water Stripping Unit which will use steam to remove the impurities. Stripped water will then be recycled for process use, for example in the Desalter. The acid gas produced will be combined with the acid gases from the Amine Absorber and fed to the SRU.

The SRU will consist of two (2) Sulphur Recovery trains utilizing the Claus Process, whereby a catalytic converter will be used to recover elemental sulphur from the acid gases. The solid sulphur will be sold as a by-product, while the tail gas produced will be fed to a Tail Gas Treating Unit (TGTU). In the TGTU, the tail gas from the SRU will first be heated in a fired heater, then passed through a reactor then finally contacted with MDEA, thus removing most of the sulphur which remained in the tail gas from the SRU in the form of elemental sulphur. The treated gas will then be incinerated in a boiler and the MDEA regenerated.

Waste Water Treatment

Waste water will first enter an oil water separator then undergo additional treatment, possibly consisting of a dissolved air flotation system, as is used in many refineries worldwide. The exact configuration is unknown at this time; however, all waste water will undergo the requisite treatment to meet the national effluent standards prior to disposal.

Utilities

All primary utility systems as listed below will be upgraded to meet the demands of the upgraded refinery.

Boiler facilities will be upgraded to produce the increased steam demand.

Additional Cooling Towers will be installed.

The fuel gas system will be upgraded to satisfy the increased demand arising from the installation of new fired heaters

The existing flare will be replaced with one of larger capacity. Flaring is an environmentally acceptable method for safe disposal of refinery waste gases.

An acid gas flare will also be installed to safely dispose of waste gases with high H_2S content.

Additional Reverse Osmosis Plants for treatment of well water will be installed. The feed water will be extracted from new wells, the locations of which are being determined through a comprehensive geological survey so as to minimize the potential environmental impact.

Additional compressors will be installed to supply the required instrument and utility air.

The upgraded refinery will also see the installation of a hydrogen production plant using steam methane reforming (SMR) and pressure swing absorption (PSA) technology, and also a nitrogen production plant using PSA technology.

Electricity and steam will be purchased from the neighbouring JPS plant from a newly installed Cogeneration unit. The arrangement will be one of synergy, as Petrojam will supply JPS with the petcoke which will be used for the generation of electricity and steam. Petrojam will in turn return the condensate to JPS.

Map of Kingston, Jamaica showing the Petrojam site location

Terms of Reference

The Environmental Impact Assessment will include but not be limited to the following:

1) Objectives

2) Complete description of the existing site proposed for development.

3) Significant environmental issues of concern through the presentation of baseline data which should include social, cultural and heritage considerations. Assess public perception of the proposed development.

4) Policies, Legislation and Regulations relevant to the project.

5) Likely impacts of the development on the described environment, including direct, indirect and cumulative impacts, and their relative importance to the design of the development's facilities.

6) Mitigation action to be taken to minimise predicted adverse impacts and quantify associated costs.

7) Monitoring Plan which should ensure that the mitigation plan is adhered to.

8) Alternatives to the project that could be considered at that site or at any other location.

9) Conclusions

The following tasks will be undertaken:

Task #1: Description of the Project

Provide a comprehensive description of the project and its surrounding environment specifying any information necessary to identify and assess the environmental effects of the project. This should include project objectives and information on the nature, location/ existing setting, timing, duration, frequency, general layout and size of facility including ancillary buildings and storage facilities, pre-construction activities, construction methods, works and duration, and post construction plans and also procedures for planning modifications to and/or the design of facilities. A description of raw material inputs, technology and processes to be used as well as products and by-products generated, should be provided. Note areas to be reserved for construction and areas to be preserved in their existing state as well as activities and features which will introduce risks or generate impact (negative and positive) on the environment.

Wastewater and sewage treatment systems including treated effluent disposal will be clearly outlined as well as solid waste disposal methods. In addition, plans for surface/storm water collection and disposal as well as plans for providing utilities and other services will be clearly stated. This will involve the use of maps at appropriate scales, site plans, aerial photographs and other graphic aids and images, as appropriate.

In terms of beach modification, any proposed works on the foreshore and the floor of the sea will be clearly described including but not limited to any seagrass or coral removal and replanting.

A storm surge analysis must be conducted to inform coastal setbacks of buildings and impact mitigation structures/measures.

All phases for the project will be clearly defined the relevant time schedules, phased maps, diagrams and appropriate visual aids will be included.

Task #2: Description of the Environment. /Baseline Studies Data Collection and Interpretation

The study area/geographical boundaries, and methodology to be utilized for baseline and other data and the length of the study will be described. The areas/geographical boundaries will depend on the relevant parameter and the selection of these areas must be justified. This task involves the generation of baseline data which is used to describe the study area as follows:

i) Physical environment

ii) Biological environment

iii) Socio-economic and cultural constraints.

(A) Physical

i) A detailed description of the existing **soil and geology and geomorphology, landscape, aesthetic values** and **hydrology.** Special emphasis will be placed on storm water run-off, drainage patterns, aquifer characteristics, effect on groundwater and availability of potable water. Any slope stability issues that could arise should be thoroughly explored.

ii) **Water quality** of any existing wells, rivers, ponds, streams or coastal waters in the vicinity of the development. Quality Indicators should include but not necessarily be limited to nitrates, phosphates, faecal coliform, and suspended solids.

iii) **Coastal and Marine** ecosystems, including but not limited to any wetlands including mangroves, seagrass and coral community with indication of its function and value in the project area.

iv) **Climatic conditions and air quality** in the area of influence including particulate emissions from stationary or mobile sources, NO_x, SO_x, wind speed and direction, precipitation, relative humidity and ambient temperatures,

v) **Noise levels** of undeveloped site and the ambient noise in the area of influence.

vii) Obvious sources of existing **pollution** and extent of contamination.

viii) Availability of **solid waste** management facilities.

(B) Biological

Present a detailed description of the flora and fauna (terrestrial and aquatic) of the area, with special emphasis on rare, threatened, endemic, protected, endangered species. Migratory species wild food crop plants and presence of invasive alien species should also be considered.

There may be the need to incorporate micro-organisms to obtain an accurate baseline assessment. Generally, species dependence, habitats/niche specificity, community structure and diversity ought to be considered.

(C) Socio-economic & Cultural

Present and projected population; present and proposed land use; planned development activities; issues relating to squatting and relocation; (housing demand and supply) community structure; economic base /employment; distribution of income; goods and services; utilities; recreation; public health and safety; cultural peculiarities, aspirations and attitudes should be explored. The historical importance (heritage, archaeological sites and feature) and other material assets of the area should also be examined. While this analysis is being conducted, it is expected that an assessment of public perception of the proposed development be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings or questionnaires/surveys.

Task #3: Policy, Legislative and Regulatory Considerations

Outline the pertinent regulations and standards governing environmental quality, safety and health, protection of sensitive areas, protection of endangered species, citing and land use control at the national and local levels. The examination of the legislation should include at minimum, legislation such as the NRCA Act, the Housing Act, the Town and Country Planning Act, The Petroleum Act, Building Codes and Standards, Development Orders and Plans and the appropriate international convention/protocol/treaty where applicable.

Task #4: Identification and Assessment/Analysis of Potential Impacts

Identify the significant environmental and public health/safety issues of concern and indicate their relative importance. These should include the occupational exposure, health and safety measures and population exposure in the appropriate study areas and changes and or enhancements in emergency response plans.

Identify the nature, severity, size and extent of potential direct, indirect and cumulative impacts (for terrestrial and aquatic environments) during the pre-construction, construction and operational phases of the development as they relate to, (but are not restricted by) the following:

change in drainage patterns

flooding potential

landscape impacts of excavation and construction

loss of and damage to geological and palaeontological features

loss of species and natural features

habitat loss and fragmentation species

biodiversity/ecosystem functions

pollution of potable, coastal, marine, surface and ground water

air pollution

capacity and design parameters of proposed sewage treatment facility

Socio-economic and cultural impacts.

Impact of flooding, loss of natural features, excavation and construction on the historic landscape, architecture and archaeology of the site.

risk assessment

noise and vibration

solid waste

soil

access to resources such as beaches

carrying capacity of the proposed site

Identify the interaction between different impacts and impacts of other projects should also be considered. In addition, the impacts that have occurred and those impacts which could still occur as a consequence of the clearing works that were conducted on the site prior to the preparation of the TORs should also be identified and analysed

Distinguish between significant positive and negative impacts, reversible or irreversible direct and indirect, long term and immediate impacts as well as avoidable and irreversible impacts.

Characterize the extent and quality of the available data, explaining significant information deficiencies, assumptions and any uncertainties associated with the predictions of impacts. A major environmental issue is determined after examining the impact (positive and negative) on the environment and having the negative impact significantly outweigh the positive. It is also determined by the number and magnitude of mitigation strategies which need to be employed to reduce the risk(s) introduced to the environment. Project activities and impacts should be represented in matrix form with separate matrices for pre- and post-mitigation scenarios.

Task #5: Drainage Assessment

An assessment of Storm Water Drainage should be conducted. The EIA Report should cover, but not limited to:

Drainage for the site during construction, to include plans for the management of storm water, mitigation of sedimentation to the aquatic environment

Drainage for the site after the upgrade, to include plans for the management of storm water, mitigation of sedimentation to the aquatic environment

Drainage control for the gully traversing the property, to include impacts that this drain will have on the aesthetics, water quality and sedimentation of the beach area, etc.

Task #6: Mitigation

Prepare guidelines for avoiding or reducing (e.g. restoration and rehabilitation), as far as possible, any adverse impacts due to proposed usage of the site and utilising of existing environmental attributes for optimum development. Quantify and assign financial and economic values to mitigating methods.

Task #7: Environmental Management and Monitoring Plan

Design a plan for the management of the natural, historical and archaeological environments of the project to monitor implementation of mitigatory or compensatory measures and project impacts during construction and occupation/operation of the units/facility. An Environmental Management Plan and Historic Preservation Plan (if necessary) for the long term operations of the site should also be prepared.

An outline monitoring programme should be included in the EIA, and a detailed version submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development. At the minimum the monitoring programme and report should include:

Introduction outlining the need for a monitoring programme and the relevant specific provisions of the permit and/or licence(s) granted.

The activity being monitored and the parameters chosen to effectively carry out the exercise.

The methodology to be employed and the frequency of monitoring.

The sites being monitored. These may in instances, be pre-determined by the local authority and should incorporate a control site where no impact from the development is expected.

Frequency of reporting to NEPA

The Monitoring report should also include, at minimum:

Raw data collected. Tables and graphs are to be used where appropriate

Discussion of results with respect to the development in progress, highlighting any parameter(s) which exceeds the expected standard(s).

Recommendations

Appendices of data and photographs if necessary.

Task #8: Project Alternatives

Examine alternatives to the project including the no-action alternative. This examination of project alternatives should incorporate the use history of the overall area in which the site is located and previous uses of the site itself. Refer to NEPA guidelines for EIA preparation.

Task #9: Public Participation/Consultation Programme

Conduct a public presentation on the findings of the EIA to inform, solicit and discuss comments from the public on the proposed development.

Document the public participation programme for the project.

Describe the public participation methods, timing, type of information to be provided to the public, and stakeholder target groups.

Summarise the issues identified during the public participation process

Discuss public input that has been incorporated into the proposed project design; and environmental management systems

All Findings must be presented in the **EIA report** and must reflect the headings in the body of the TORs, as well as references. Ten hard copies and an electronic copy of the report should be submitted to the National Environment and Planning Agency.

The report should include an appendix with items such as maps, site plans, the study team, photographs, TOR and other relevant information.

9.2 Road Map and Assessment of Conformance with Equator Principles

Table 9-1 Road Map and Assessment of Conformance with Equator Principles

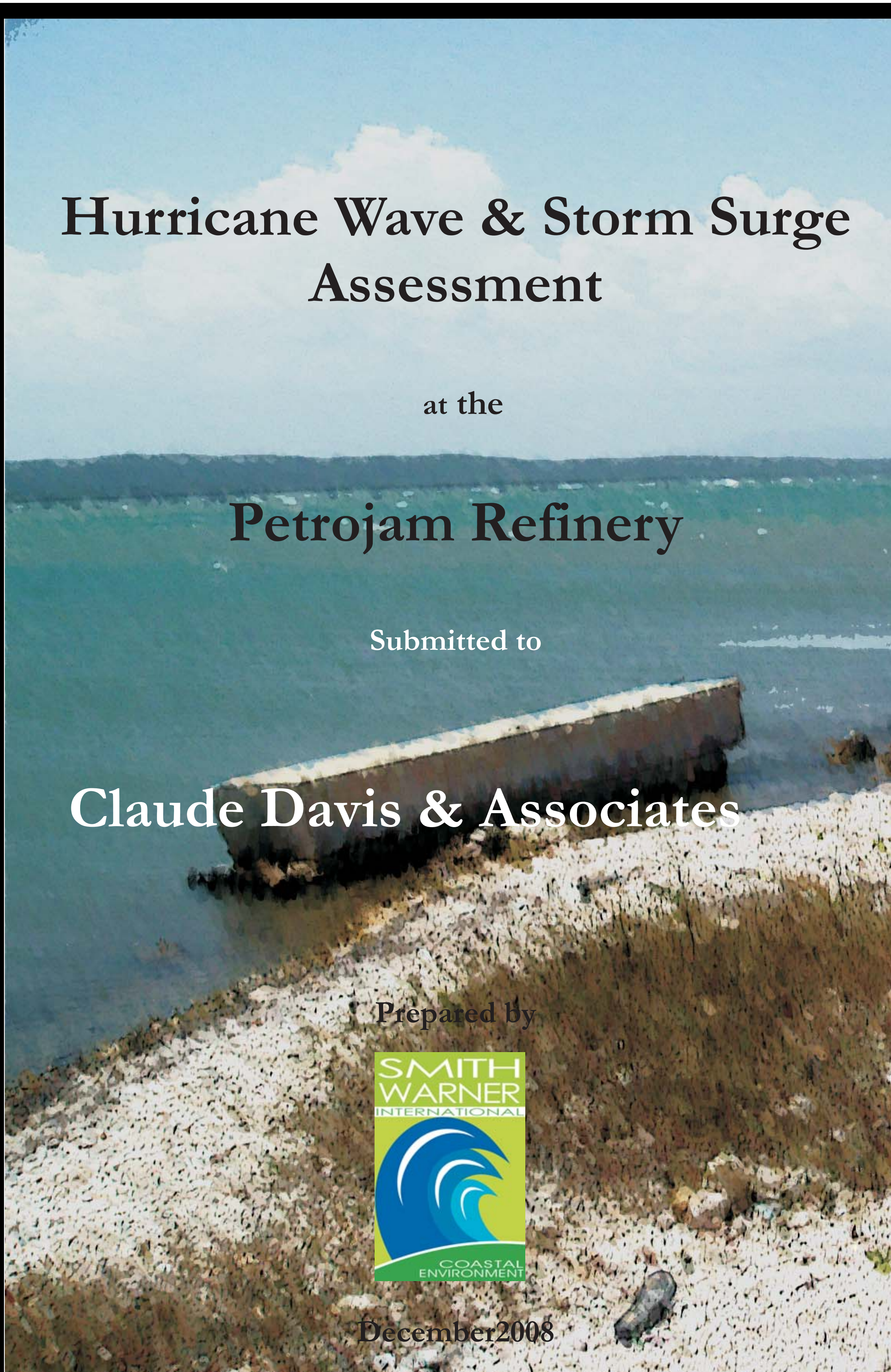
Principle	Comment (Section in EIA Report)
Principle 1: Review and Categorisation The risk of the project is categorized in accordance with internal guidelines based upon the environmental and social screening criteria of the IFC. Projects are classified, relating to social or environmental impacts, in Category A (significant impacts), Category B (limited impacts) and Category C (minimal or no impacts).	Categorised based on a quantitative assessment matrix (Section 6)
Principle 2: Social and Environmental Assessment For all medium or high risk projects (Category A and B projects), sponsors complete an Environmental Assessment, the preparation of which must meet certain requirements and satisfactorily address key environmental and social issues.	(Entire document)

Principle	Comment (Section in EIA Report)
Principle 3: Applicable Social and Environmental Standards The Environmental Assessment report addresses baseline environmental and social conditions, requirements under host country laws and regulations, applicable international treaties and agreements, sustainable development and ~~use of renewable natural resources~~, protection of human health, cultural properties, and biodiversity, including endangered species and sensitive ecosystems, use of dangerous substances, major hazards, occupational health and safety, fire prevention and life safety, socio-economic impacts, ~~land acquisition~~ and land use, ~~involuntary resettlement, impacts on indigenous peoples and communities~~, cumulative impacts of existing projects, the proposed project, and anticipated future projects, participation of affected parties in the design, review and implementation of the project, consideration of feasible environmentally and socially preferable alternatives, efficient ~~production, delivery and~~ use of energy, pollution prevention and waste minimization, pollution controls (liquid effluents and air emissions) and solid and chemical waste management.	Aspects that are not applicable are indicated with strikeout text. This is because there will be no land acquisition nor are there indigenous people or communities in the study area. There will be no production or delivery of energy (electricity) (Sections 4, 5 and 6).

Principle	Comment (Section in EIA Report)
Principle 4: Action Plan and Management System Based on the Environmental Assessment, Equator banks then make agreements with their clients on how they mitigate, monitor and manage those risks through a 'Social Environmental Management Plan'.	Section 7 provides mitigation measures and management and monitoring plans that can form the basis for such agreements. Licences issued by NEPA will be required and these may contain management plans and ambient monitoring plans and reporting and other commitments to meet standards if there is non-compliance (sic Action Plans (AP)). So far community liaison has not been a requirement of such licences. Petrojam will continue to maintain its Community Outreach activities (see Section 4.1.9).
Principle 5: Consultation and Disclosure For risky projects, the borrower consults with stakeholders (NGOs and project affected groups) and provides them with information on the risks of the project. The borrower has to consult the project affected communities in a structured and culturally appropriate manner. The process will ensure free, prior and informed consultation for affected communities.	Included in the EIA (Social Impact Assessment (Sections 4 and 6) and Public Consultation (Section 3))
Principle 6: Grievance Mechanism The borrower will establish a grievance mechanism as part of the management system.	There is no formal grievance mechanism but there is opportunity to address community issues/grievances through the Community Outreach Committee (Section 4.1.9).

Principle	Comment (Section in EIA Report)
Principle 7: Independent Review For the Assessment, Assessment Plan and consultation process.	NEPA's EIA process includes formal independent reviews of the EIA
Principle 8: Covenants - Incorporation of covenants linked to compliance Compliance with the plan is required in the covenant. If the borrower doesn't comply with the agreed terms, the bank will take corrective action, which if unsuccessful, could ultimately result in the bank cancelling the loan and demanding immediate repayment. Compliance with: relevant social and environmental laws, regulations and permits Action Plans during construction and after the upgrade Reporting requirements Decommissioning requirements	Not applicable at this stage See Principle 4 See Principle 4 See Principle 4 Not applicable at this stage. At the end of the useful life of the refinery any decommissioning requirements would be met.
Principle 9: Independent Monitoring and Reporting Over the life of the loan, in Category A and, if necessary in Category B, an independent expert is consulted.	Not applicable at this stage
Principle 10: EPFI Reporting Each EPFI commits to report publicly at least annually about its Equator Principles implementation processes and experience.	Not applicable at this stage

9.3 STORM SURGE ANALYSIS



Hurricane Wave & Storm Surge Assessment

at the

Petrojam Refinery

Submitted to

Claude Davis & Associates

Prepared by

SMITH WARNER INTERNATIONAL
COASTAL ENVIRONMENT

December2008

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1. Introduction

Smith Warner International Limited (SWI) was contracted by SeaControl Limited to conduct a storm surge investigation for the Petrojam Limited (Petrojam) oil refinery facility located on Marcus Garvey Drive, Kingston. The scope of work involves a Hurricane Wave Hindcast Analysis to investigate the wave climate and storm surge during extreme conditions in the vicinity of the Petrojam Refinery.

The site is located east of Port Bustamante, within Hunt's Bay, Kingston Harbour (Figure 1.1and Figure 1.2). The site is protected by the Palisadoes strip from regular and hurricane-generated wave action and is mostly vulnerable to waves generated inside Kingston Harbour during extreme events.

Figure 1.1 Kingston Harbour with the Petrojam Refinery highlighted in red (Google Earth©)

Figure 1.2 A closer view of the Petrojam Refinery (Google Earth©)

2. Bathymetry of Project Area

The bathymetry for the site was generated from existing data located in the SWI database. These data were collected for previous investigations done within Kingston Harbour and will be used to provide the base input for the storm surge modeling. Figure 2.1 following shows the water depths in the vicinity of the Petrojam Refinery. The Port Bustamante channel is indicated in dark blue.

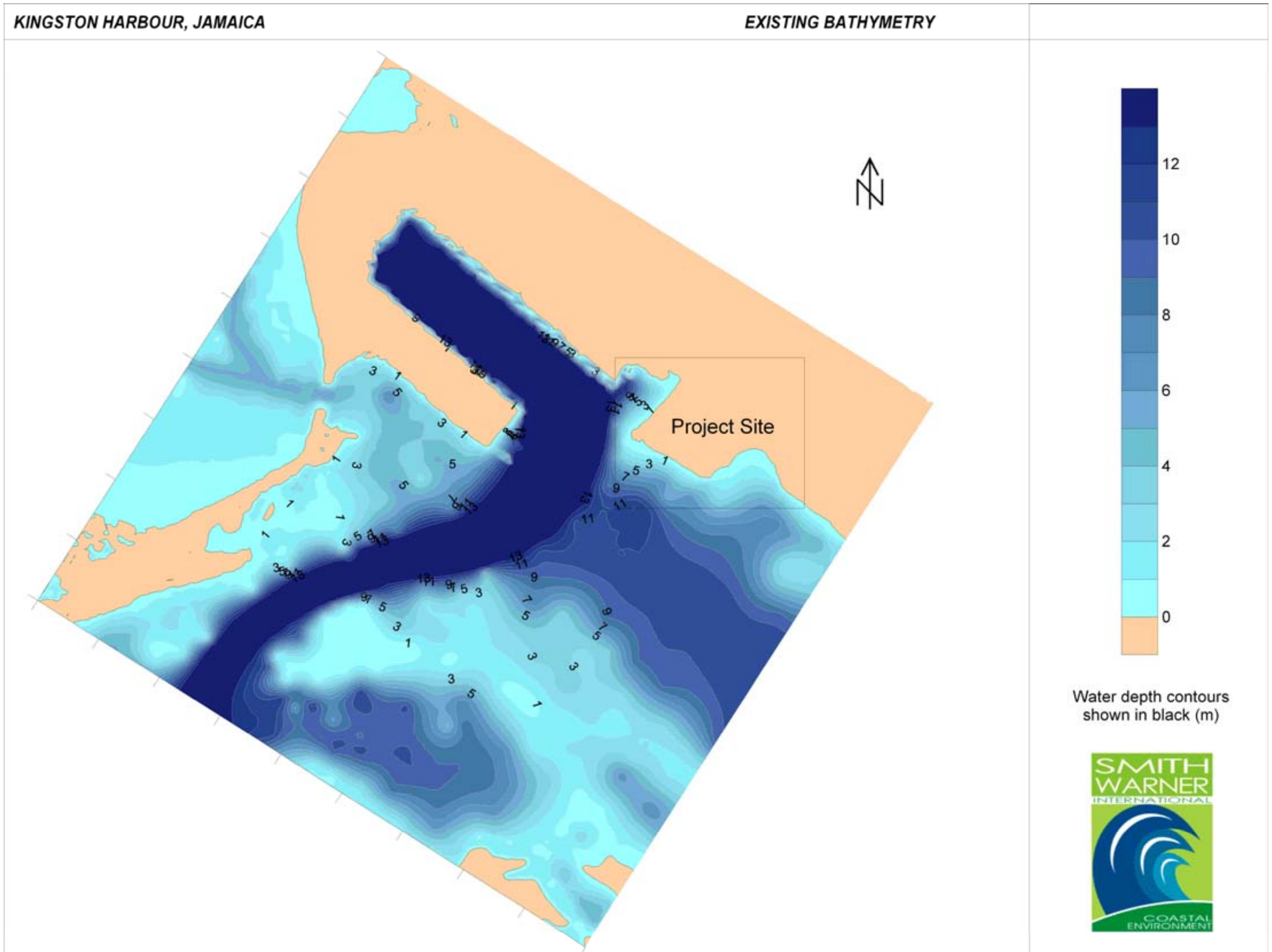


Figure 2.1 Bathymetric plot showing water depths in the Project area and vicinity

3. Hurricane Waves

Tropical cyclones are naturally occurring phenomena characterized by high velocity winds and centres with low pressure. The winds increase in speed to a maximum near the center, or eye, while atmospheric pressure increases from a low point as the distance from the eye increases. The high velocity winds are able to generate waves of considerable height, while the low pressure centre raises the sea level underneath the eye.

A tropical cyclone is classified as a hurricane only after it has attained one-minute maximum sustained near-surface (10 m) winds of 33 m/s or more. Below this, these storms are referred to as Tropical Storms. Hurricanes are commonly classified into categories according to the Saffir Simpson Hurricane Intensity Scale.

The occurrence of hurricanes is difficult to predict based on short-term analysis, but the accuracy of predictions can be markedly improved by taking into consideration the history of occurrences of hurricanes over a long period of time. The method of using past storm and hurricane occurrences to predict the intensities of future ones is called *hindcasting*.

An in-house computer program, HurWave, was used for hindcasting for this project. This program was developed initially to calculate design wave heights and peak wave periods for different return periods. The program includes a complete database of all storms and hurricanes occurring in the North Atlantic and the Caribbean from 1900 to present, with data taken from the USA's National Oceanic and Atmospheric Administration (NOAA).

Using data from the tracks of each tropical storm or hurricane, HurWave selected storm events that passed within a 300 km radius of the Petrojam Refinery site. For each event, the significant wave height, peak wave period, maximum wind speed and corresponding central pressure were determined for a series of points along the track. Probabilistic analysis was then done to determine the 50 and 100-year storm conditions and the associated exceedance probability, which is discussed in more detail in the following sections.

It was observed from the HurWave output that a total of 104 storm events passed within a 300 km radius of the site since 1900. The breakdown of the number of storm events falling within each category of the Saffir Simpson scale is given in Table 3-1 following.

Table 3-1 Summary of storms passing within 300 km of the Petrojam Refinery from 1900 to 2007

Hurricane Category	*Number of Events*	*Wind Speed (m/s)*	*Wind Speed (km/h)*
Tropical Storm	62	18 – 33	64 – 118
1	17	33 – 43	119 – 154
2	10	44 – 49	155 – 178
3	7	50 – 58	179 – 210
4	6	59 – 70	211 – 250
5	2	> 70	> 250

Figure 3.1 shows the temporal distribution of these storm events since 1900. Figure 3.2 shows the hurricane tracks that were classified as Category 3 and greater on the Saffir Simpson Hurricane Intensity scale, and which have passed within 300 km of the site. In this list are hurricanes such as Gilbert (1988), Ivan (2004) and Dean (2007). Ivan and Dean caused serious damage when they passed south of the island as Category 4 storms. Gilbert (1988), Cleo (1964) and Charlie (1951) are other memorable hurricanes that have affected the country as a whole.

Hurricanes, as well as less intense storms, generate waves in all directions from the intense wind field spiraling from their centre. Figure 3.3 shows a directional distribution of the estimated wave heights for all hurricanes in the database from 1900. The hurricane wave heights were estimated using a parametric wave model developed by Young[1].

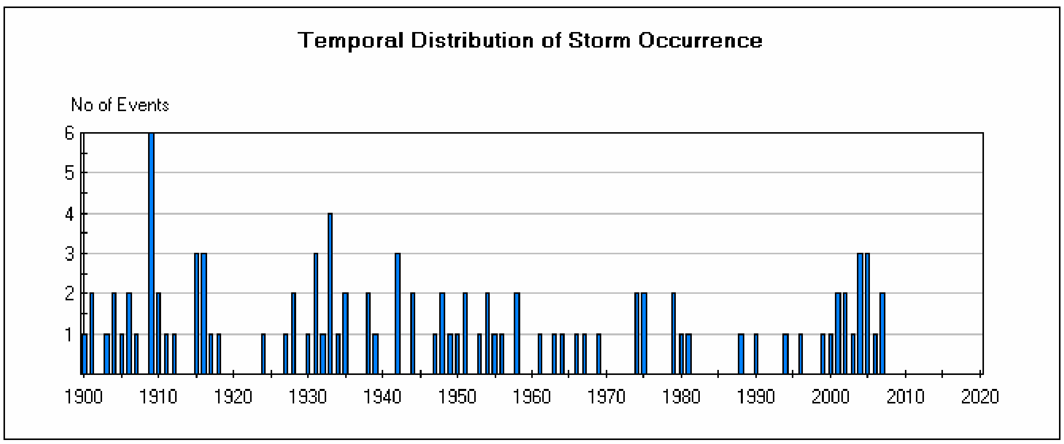


Figure 3.1 Temporal distribution of tropical storm/hurricane occurrence

[1] Young, I.R., 1988. *A Parametric Model for Tropical Cyclone Waves.* Research Report No. 28, University of New South Wales.

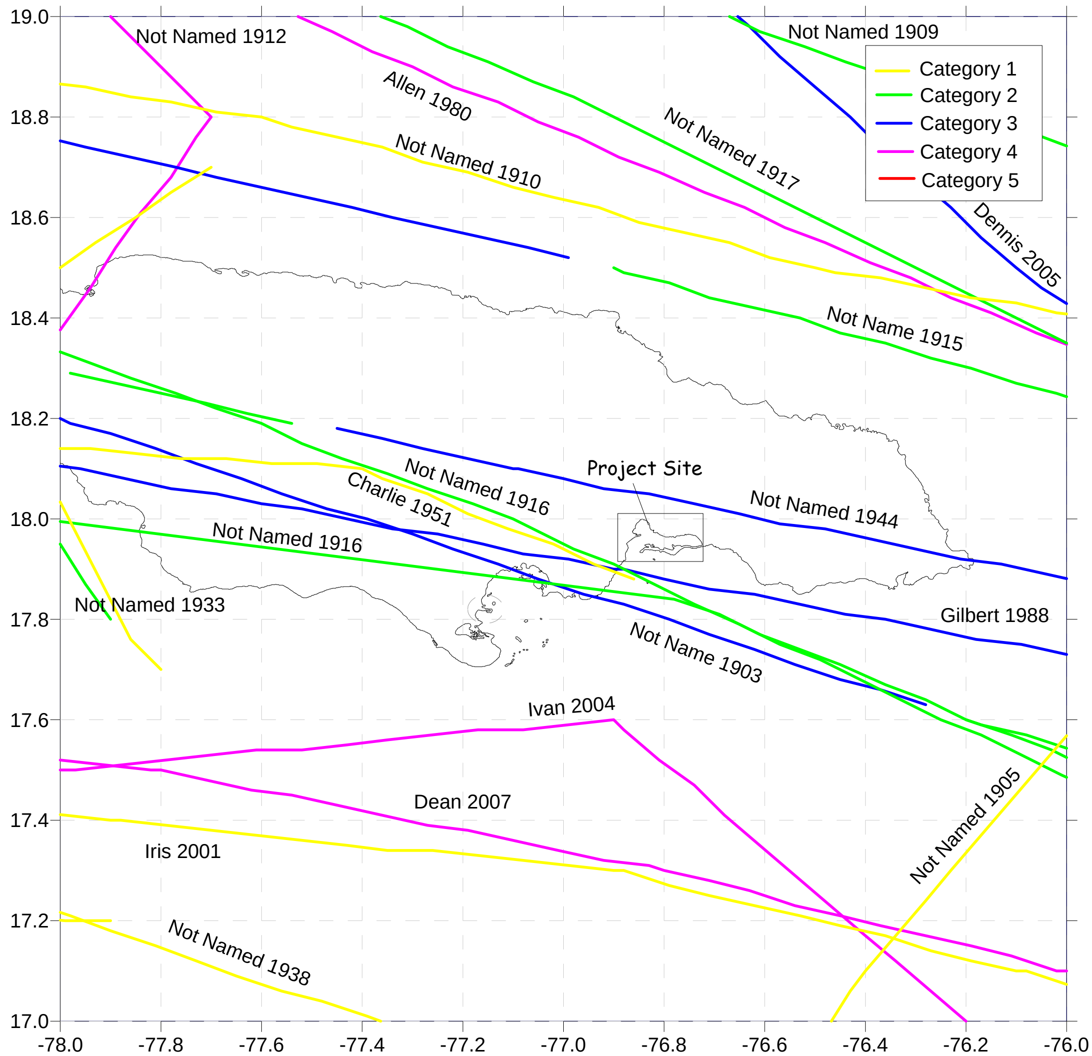


Figure 3.2 Category 3 (and Greater) Storms that have passed within 300km of the Petrojam Refinery during the last 100 years

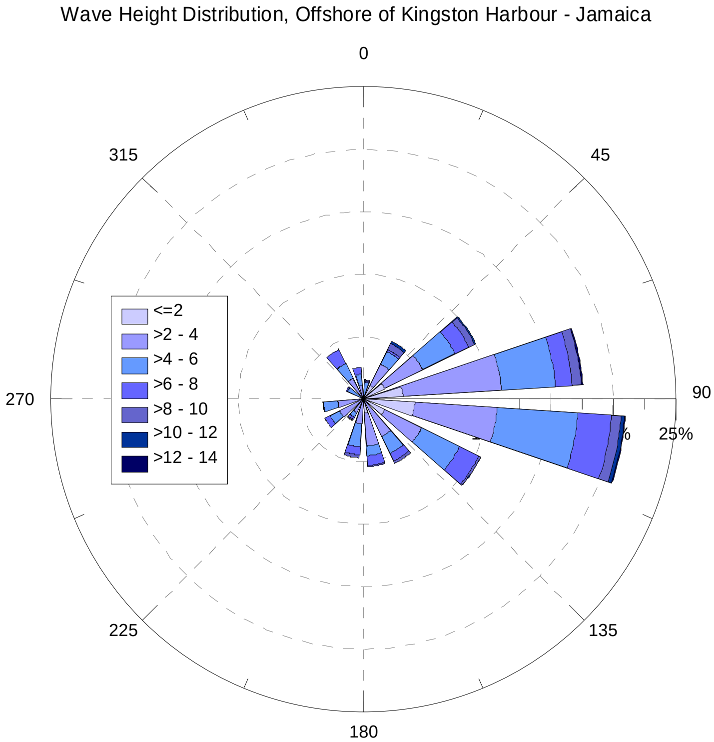


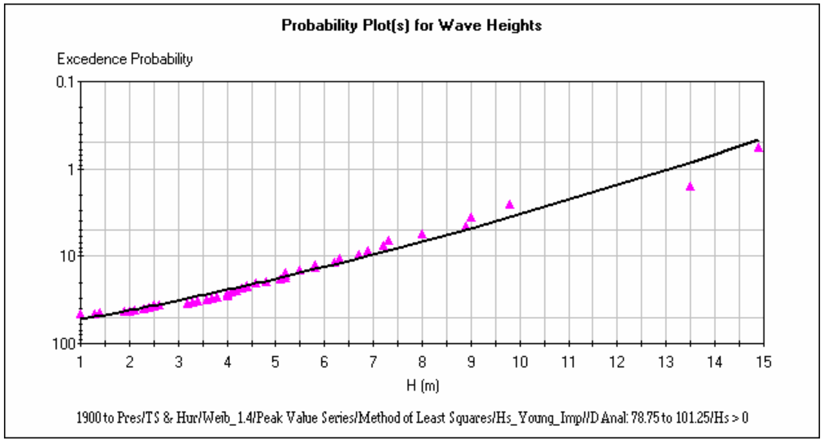
Figure 3.3 Directional distribution of hurricane wave heights off Kingston Harbour

The above plot shows that storm waves approach predominantly from the east. This is because of the typical west-north-westerly tracks of the hurricanes and the anticlockwise rotating wind field that characterizes these cyclones. The south coast of Jamaica typically is exposed to the waves in the bottom right quadrant of the approaching hurricanes.

Because of the location and general nature of the site, only waves approaching from the southerly sectors are able to enter directly into Hunt's Bay. However waves generated by easterly winds inside Kingston Harbour can have an impact on the project site.

An extremal statistical analysis was carried out to calculate the significant wave height, peak wave period and wind speeds that are characteristic of different hurricane return periods. The analysis took into account waves approaching from offshore in deep water (water depths greater than 200m) and coming from all the eastern to southern directions. Similar to the wave directional plot in Figure 3.3 above, the critical wave heights were shown to be coming from the east and east-south-east. Figure 3.4 shows an exceedance plot of the wave heights approaching from the east and southeast directions using the Weibull k-value distribution.

Table 3-2 shows the wave heights and peak wave periods and wind speeds for the various return periods. From this directional analysis of the hurricane waves, it is seen that those waves coming from the east have had the greatest wave heights, followed by those coming from the south-east. Waves from the more southerly directions, however, are expected to have a greater impact on wave conditions inside the Kingston Harbour, as they are better able to directly enter the harbour.



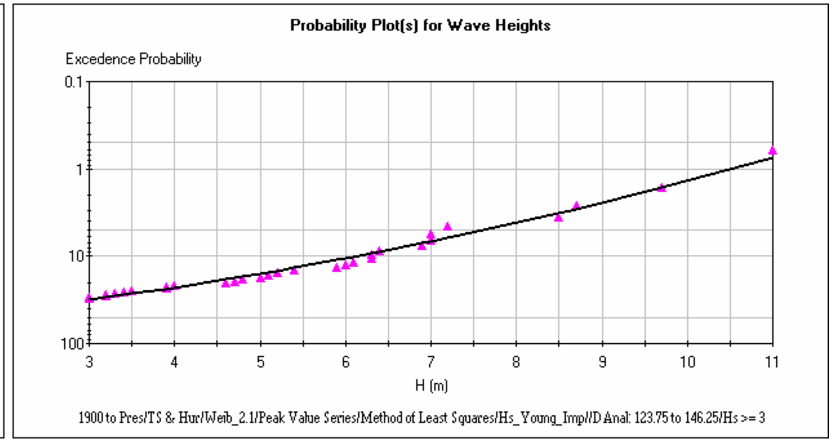


Figure 3.4 Exceedance plot of deep water hurricane wave heights offshore Kingston Harbour for the east (left) and south-east (right).

Table 3-2 Directional wave conditions resulting from the extreme wave analysis for various return periods

SECTOR	1			2			3			4			5			6			7		
	East 78.75° to 101.25°			East-Southeast 101.25° to 123.75°			Southeast 123.75° to 146.25°			South Southeast 146.25° to 168.75°			South 168.75° to 191.25°			South-Southwest 191.25° to 213.75°			Southwest 213.75° to 236.25°		
Rp (yrs)	Hs (m)	Tp (s)	Ws (m/s)	Hs (m)	Tp (s)	Ws (m/s)	Hs (m)	Tp (s)	Ws (m/s)	Hs (m)	Tp (s)	Ws (m/s)	Hs (m)	Tp (s)	Ws (m/s)	Hs (m)	Tp (s)	Ws (m/s)	Hs (m)	Tp (s)	Ws (m/s)
5	4.38	8.37	17.09	4.47	8.47	17.32	4.13	8.06	16.45	1.66	4.54	10.43	2.30	5.58	11.94	1.08	3.47	9.09	0.83	2.93	8.52
10	6.60	10.83	23.00	6.60	10.83	23.00	5.94	10.14	21.20	3.88	7.76	15.82	4.17	8.11	16.56	2.83	6.36	13.22	2.62	6.06	12.71
25	9.24	13.40	30.57	9.06	13.23	30.04	7.92	12.15	26.71	6.19	10.41	21.88	6.23	10.45	21.99	4.92	9.00	18.49	4.61	8.64	17.69
50	11.10	15.03	36.27	10.75	14.73	35.17	9.22	13.37	30.51	7.68	11.92	26.03	7.60	11.84	25.80	6.38	10.61	22.40	5.92	10.12	21.15
100	12.86	16.49	41.93	12.32	16.06	40.16	10.40	14.43	34.09	9.01	13.18	29.89	8.84	13.03	29.39	7.77	12.01	26.28	7.12	11.36	24.44
150	13.85	17.29	45.23	13.20	16.77	43.05	11.05	14.99	36.11	9.73	13.84	32.04	9.53	13.65	31.44	8.55	12.76	28.54	7.77	12.01	26.28
200	14.54	17.82	47.58	13.81	17.25	45.09	11.49	15.37	37.50	10.23	14.28	33.57	9.99	14.07	32.83	9.10	13.27	30.16	8.22	12.45	27.58

The rapid rise in water level that accompanies an intense hurricane is mainly due to the effects of strong winds and low pressure as the storm passes a given point in shallow water. The water level rise or storm surge is the static increase in the water level above mean sea level, and is made up of mainly five components, namely:

1. *The Inverse Barometric Rise (IBR)* – The IBR is the rise in the water surface elevation caused by the low pressure centre of the hurricane. It has its peak at the eye of the storm, decreasing with increased distance from the centre or eye.
2. *Highest Astronomical Tide (HAT)* – The HAT is the highest level that daily tidal variations may reach. This level can be accurately predicted and is available from tide charts. It is important to include this water level, as it is possible for the storm to occur while the sea level is already at this elevation.
3. *Global Sea Level Rise (GSLR)* – The GSLR has been predicted by scientists according to past and present rates of sea level variations and forecasting of the effects of global warming on the melting of polar ice caps. This present rate of increase for this part of the Caribbean is predicted to be approximately 0.25 m for the next 50 years.
4. *Wind Setup* – Wind setup is a result of intense winds blowing over the water surface that causes shear stresses at the water surface. This will tend to push water towards the land. This water will rise more steeply in areas where the water depth is shallow, and therefore further add to the water level rise in nearshore areas.
5. *Wave Setup* – Wave setup includes the increase in water elevation due to the dissipation of wave energy as waves approach the shoreline and start to break. During wave breaking, wave heights steepen as the wave velocity slows due to the effects of bottom friction on the seabed.

IBR levels were computed from each storm hindcast by HurWave and the data fitted to various statistical distributions. The best-fit distribution was selected based on correlation and goodness of fit to the most extreme values. Because of the non-directionality of this phenomenon, the analysis was not carried out on a directional basis. Figure 3.5 shows a plot with the water level data fitted to the Weibull distribution.

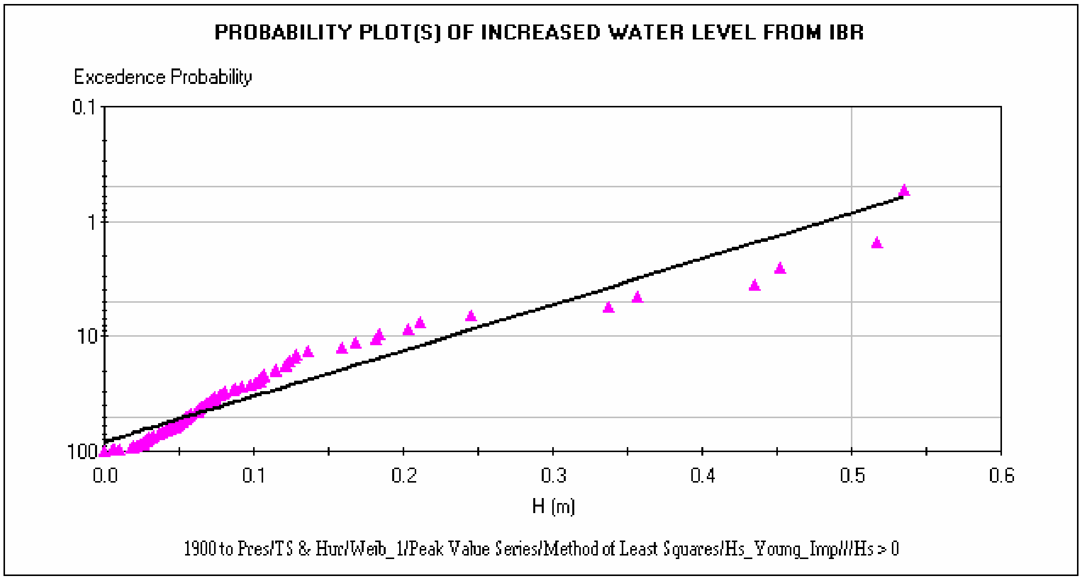


Figure 3.5 Weibull distribution of IBR

Wave and wind setup are influenced by the bathymetry, wind speed and wave height occurring at a particular point. They are, therefore, best determined by 2-dimensional modeling of the extreme wave conditions for a particular area. This is explained in more detail in Section 4 following. The remaining three factors that contribute to the total storm surge elevation (IBR, GSLR and HAT) are used as input into the 2-dimensional model. The combination of these three is called the static surge water level. Table 3-3 below provides these elevations as a function of return period. The tidal information was extracted from SWIL's database. These data were used to develop the extreme wave climate for the Petrojam Refinery.

Table 3-3 Computed Water levels for various return periods

Rp(yrs)	IBR (m)	Tide (m above sea level)	GSL (m)	Water Levels (m)
5	0.15	0.30	0.25	0.70
10	0.22	0.30	0.25	0.77
25	0.32	0.30	0.25	0.87
50	0.40	0.30	0.25	0.95
100	0.47	0.30	0.25	1.02
150	0.52	0.30	0.25	1.07
200	0.55	0.30	0.25	1.10

In the Caribbean region it is widely recommended to design coastal structure to withstand storms with 50 or 100 year return periods, depending on the amount of risk the owner is willing to take. The parametric values from both the hurricane wave and storm surge analysis corresponding to the 1-in-50 and 1-in-100 year return periods will therefore be used as input for the wave modeling process.

4. Hurricane Wave Transformation Modeling

Parametric models, such as HurWave, are limited to determining storm surge and wave conditions in deep water (greater than 200 m depth). At shallower depths, the effects of wave reflection, refraction, diffraction and shoaling of deepwater waves needs to be accounted for, while the processes of wind and wave setup need to be taken into consideration as functions of storm surge. All of these processes are dependent on the bathymetry of the nearshore. The physics of these processes are extremely complex and require equally complex numerical programs to perform proper simulations. The transformation of the deep water hurricane waves to the nearshore as well as the computation of wave setup is discussed in this section. The 1-in-50 and 1-in-100 year return period parametric data were used as input to the computer program SWAN (Simulating Waves in Nearshore Areas, Delft Institute of Technology, The Netherlands).

For the model to run effectively, all wave input boundaries have to start at depths greater than 200m in order to simulate the waves approaching the shoreline from deepwater. This meant that the model had to be run on an extensive 30m x 25m grid because of the large area of shallow water outside of Kingston Harbour extending beyond the cays to the edge of the offshore reefs. The models were run individually for each of the seven directions taken into consideration in order to reach the worst-case scenario in terms of wave height and storm surge.

Overall, the greatest wave heights and static surge values were generated for the East-Southeast direction. Figure 4.1 shows that the deep water waves are not able to penetrate into the harbour; instead the waves affecting the project area are generated inside Kingston Harbour by intense East-Southeast winds.

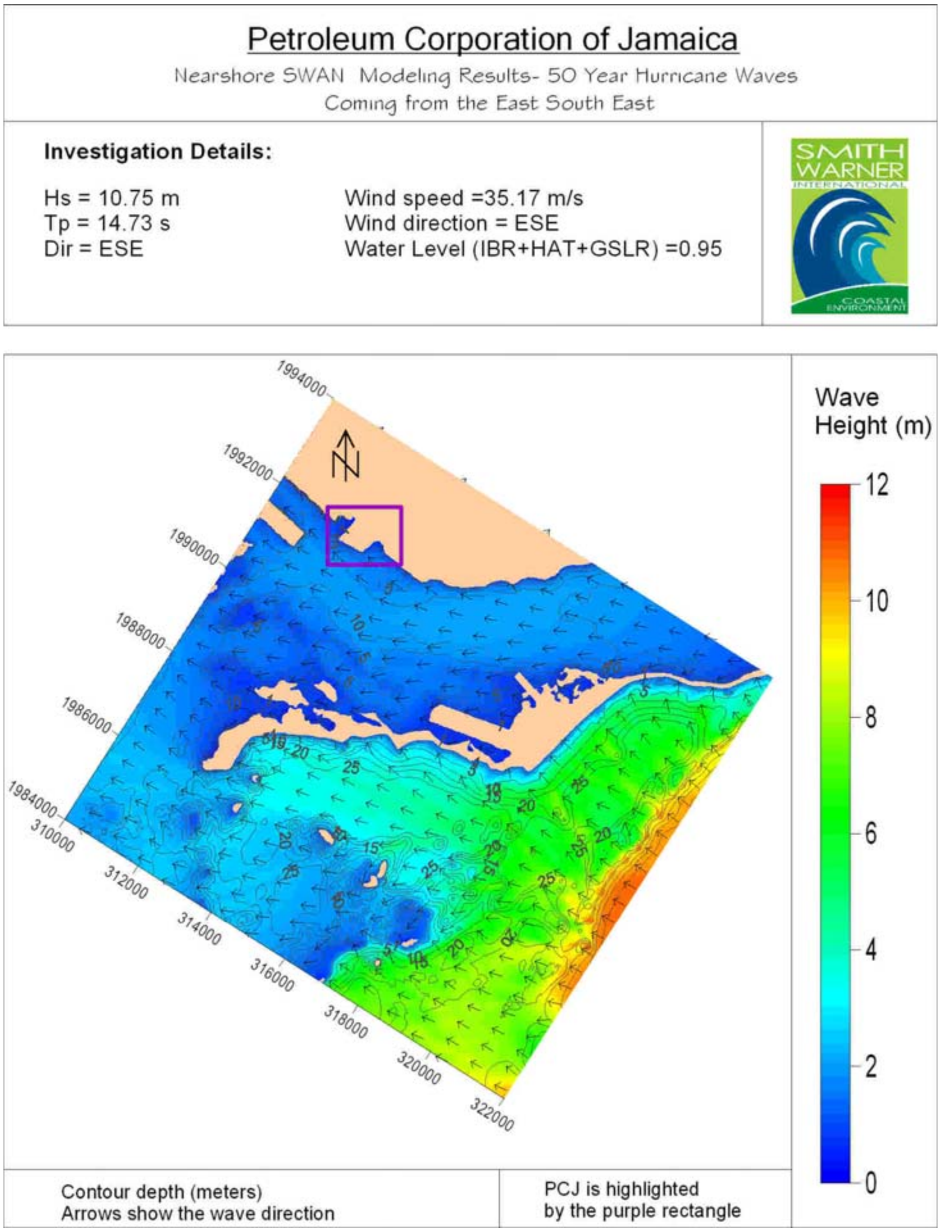


Figure 4.1 Significant wave height for 1-in-50 year Hurricane Event from the East-Southeast direction for Kingston Harbour.

Deep-water waves coming from the southwest quadrant were able to enter the harbour but they did not produce significant wave heights and storm surge values at the site. This is due to the presence of cays just outside the harbour and very shallow areas inside the harbour, which dissipate the energy of the waves before they approach the vicinity of the Petrojam Refinery. This can be seen in Figure 4.2 following.

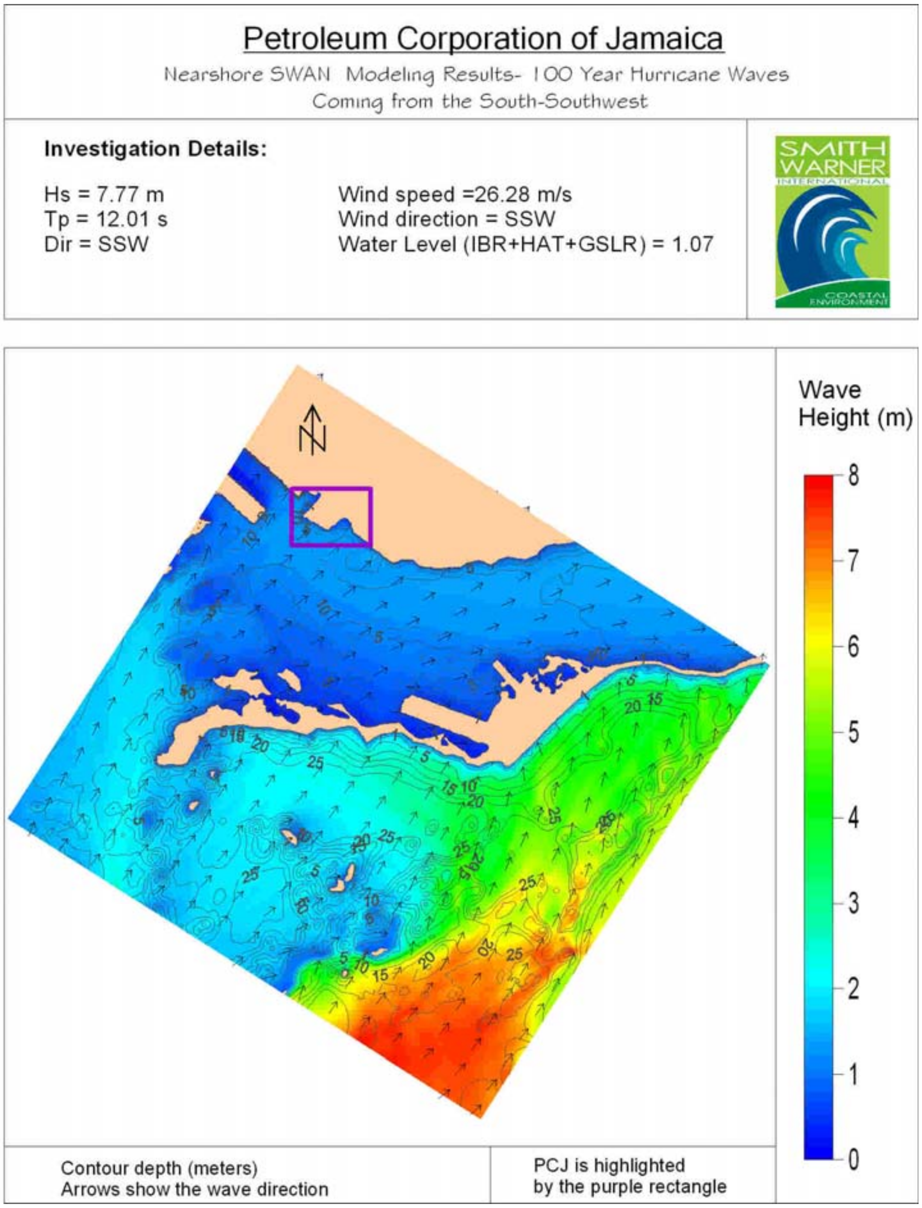


Figure 4.2 Significant wave height for 1-in-100 year Hurricane Event from the South-Southwest direction for Kingston Harbour.

The following plots show the worst-case scenario as modelled by SWAN. Figure 4.3 and Figure 4.5 show the variation in the significant wave height in the vicinity of the project site for the 50 and 100-year storms, while Figure 4.4 and Figure 4.6 show the variation of the static storm surge level.

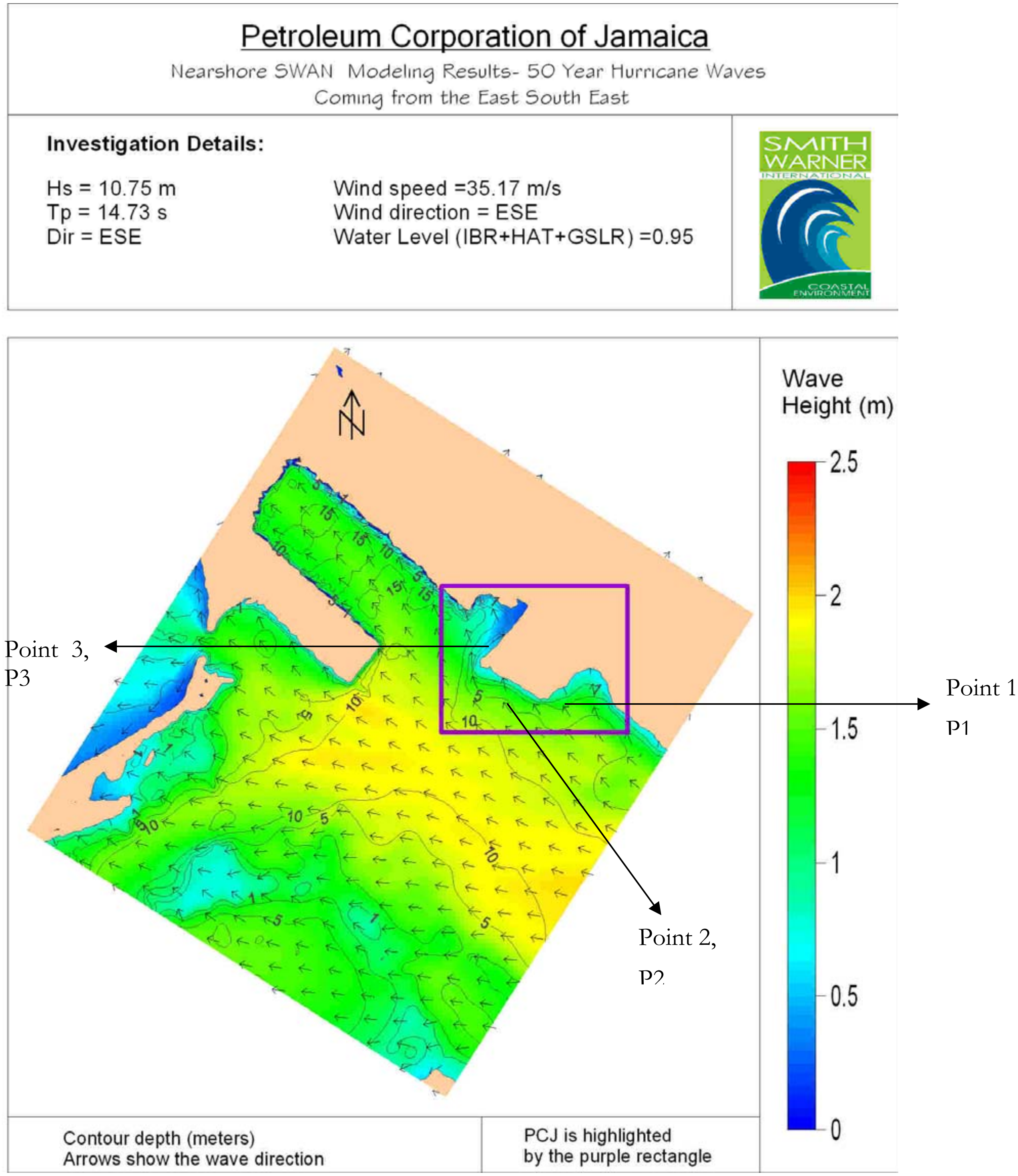


Figure 4.3 Significant wave height for 1 in 50 year Hurricane Event at PCJ

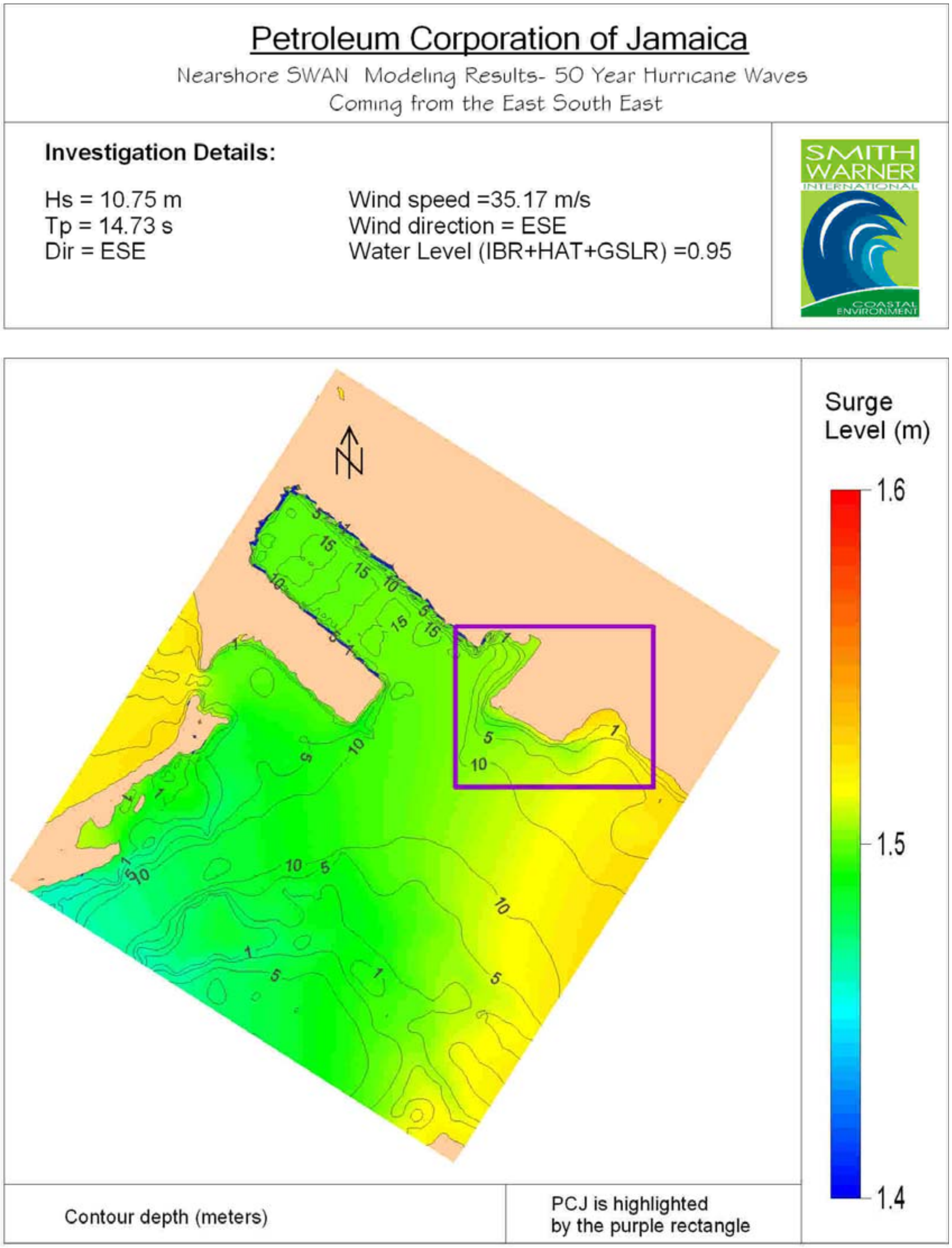


Figure 4.4 Static Storm Surge for 1-in-50 year Hurricane event at PCJ

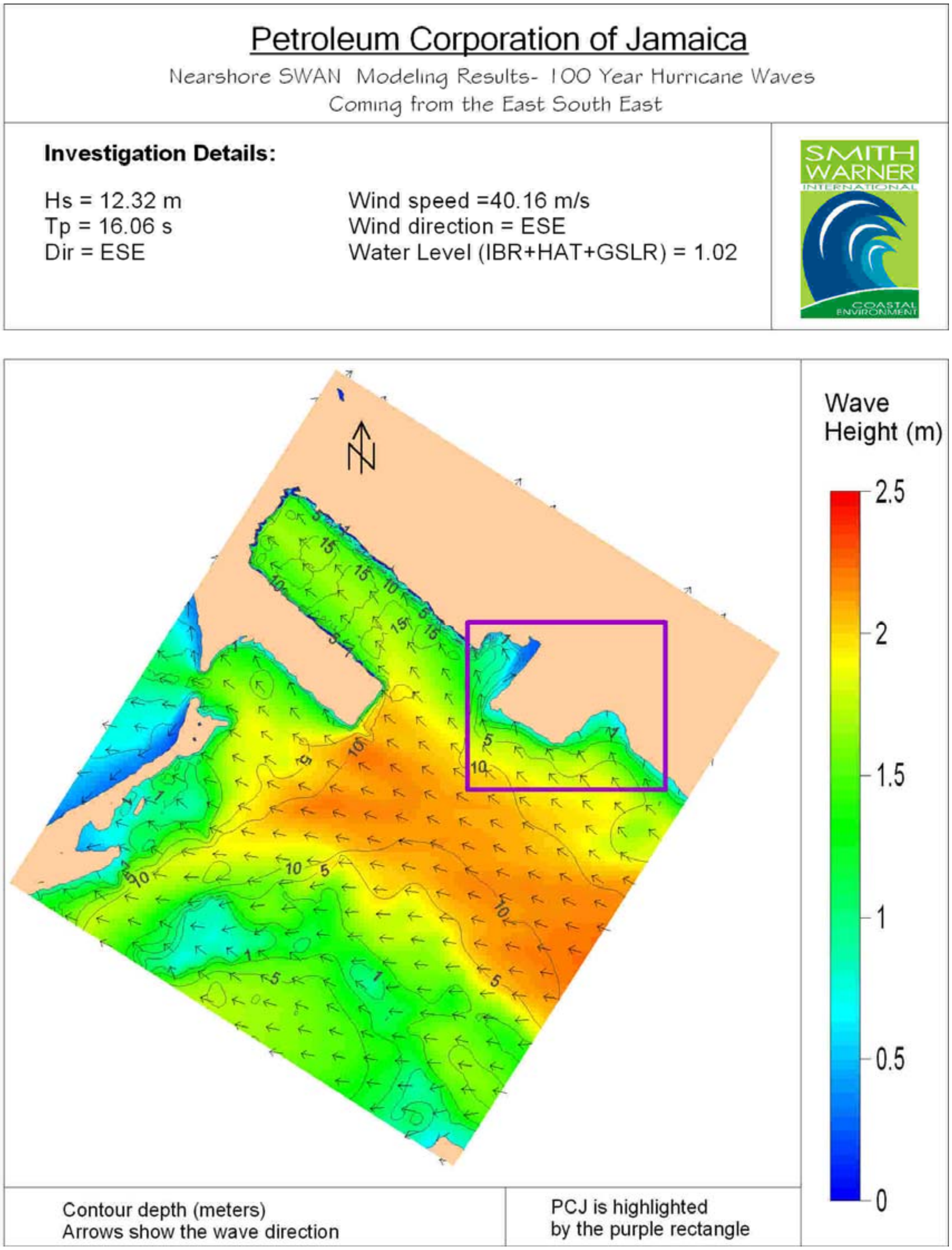


Figure 4.5 Significant wave height for 1-in-100 year Hurricane Event at PCJ

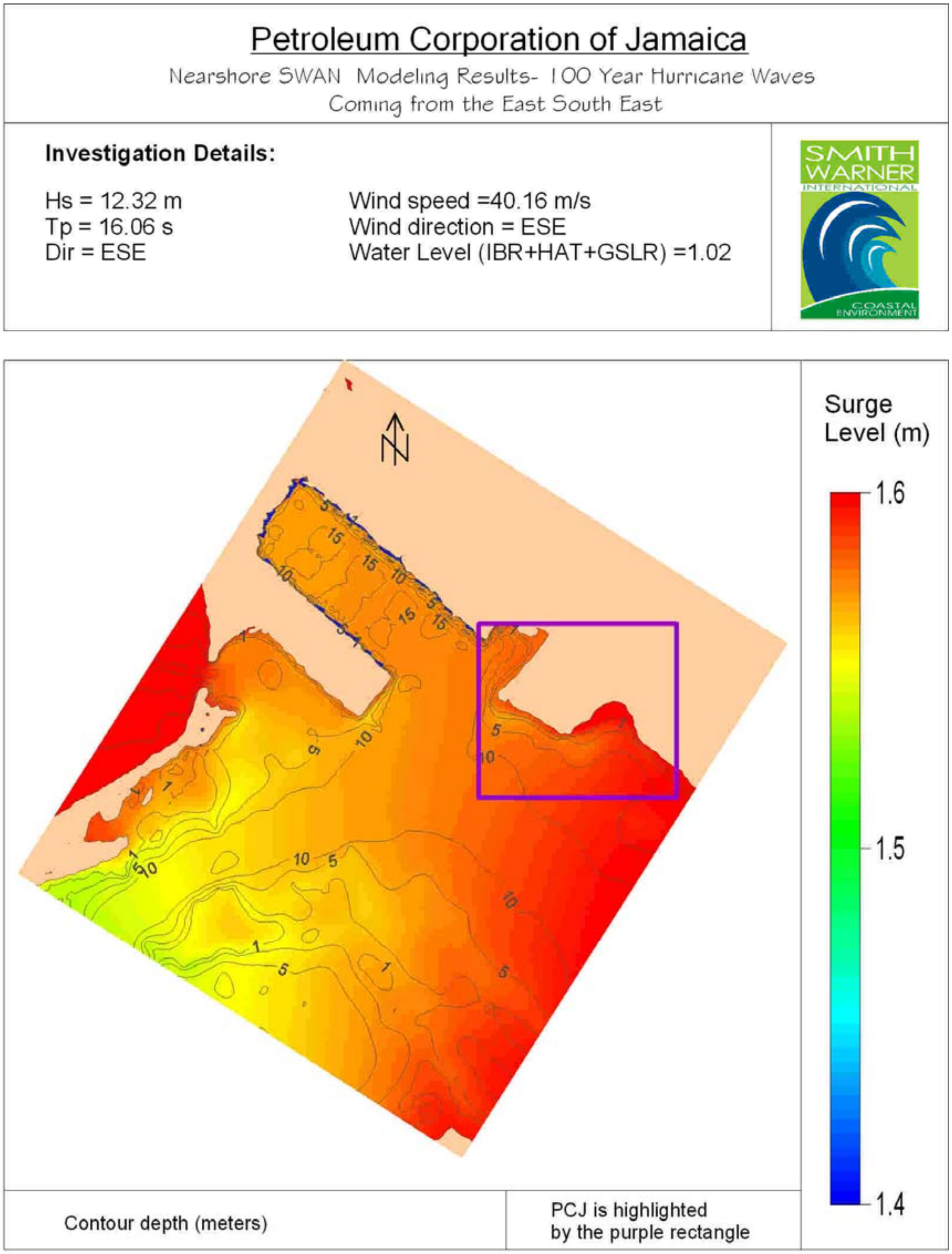


Figure 4.6 **Static Storm Surge for 1-in-100 year Hurricane event at PCJ**

5. Summary of Results

Table 5-1 and Table 5-2 below illustrate the results for the computed maximum significant wave height and static storm surge at three locations around the Petrojam Refinery for a number of return periods.

- The East-Southeast direction had the maximum wave heights for all of the return periods examined. The largest wave height values were 1.3m for the 1-in-100 year event while that of the 1-in-25 year return period was 0.5m.
- The greatest possible inundation level that can be experienced at the site is 1.73m for the 1 in 100 year return period event from the ESE direction. The SSW and SW directions had values of 1.32 m and 1.38m respectively for the same return period. These values are shown below.

Table 5-1 Summary of significant wave heights

	Eastern point, P1		Southern point, P2		Western point, P3	
Dir	**Rp (yrs)**	**Hs (m)**	**Rp (yrs)**	**Hs (m)**	**Rp (yrs)**	**Hs (m)**
ESE	25	1.11	25	1.04	25	0.47
ESE	50	1.23	50	1.18	50	0.56
ESE	100	1.31	100	1.31	100	0.71
SSW	100	1.02	100	1.09	100	0.86
SW	100	1.01	100	1.06	100	0.74

Table 5-2 Summary of static storm surge for Eastern section of Petrojam Refinery

	Point P3 located East of the site	
Dir	**Rp (yrs)**	**Static Storm Surge (m)**
ESE	25	1.49
ESE	50	1.62
ESE	100	1.73
SSW	100	1.32
SW	100	1.38

9.4 AIR QUALITY DISPERSION MODEL PREDICTIONS

Table 9-2 Model Predictions for SO_2 at Special Receptors

	Zone 18		Highest Predicted		Predicted
Receptor Name	**UTM_E (m)**	**UTM_N (m)**	**1h Average ($\mu g\ m^{-3}$)**	**24h Average ($\mu g\ m^{-3}$)**	**Annual Average ($\mu g\ m^{-3}$)**
All Saints Infant	309874	1988334	520	30	5.33
Allman Town Primary	310863	1988588	464	30	6.21
Alpha Infant	311567	1988904	495	47	11.5
Alpha Primary	311567	1988904	495	47	11.5
Boys Town All Age	308953	1988977	273	69	8.02
Calabar Infant Primary & Junior High	310792	1987942	376	24	5.51
Camperdown High	312478	1988069	356	60	11.0
Central Branch All Age	310106	1989232	622	44	8.20
Central Branch Infant	310106	1989232	622	44	8.20
Chetolah Park Primary	309901	1988870	346	29	6.00
Convent of Mercy "Alpha"	311445	1988792	373	40	9.84
Denham Town High	309200	1988605	329	45	6.64
Denham Town Primary	309200	1988605	329	45	6.64
Dunoon Park Technical High	313050	1988485	399	75	22.1
Elletson Primary and Infant	311970	1987890	309	42	8.16
Franklyn Town Primary	312032	1988742	399	53	13.3
Holy Family Primary and Infant	310963	1987798	283	25	5.68
Holy Trinity High	311096	1988450	506	33	6.28
Jessie Ripoll Primary	311539	1988540	470	38	8.21
Kingston College	311118	1988245	500	31	6.00
Kingston High	310321	1988935	490	35	7.19
Kingston Technical High	310663	1988235	527	28	5.42
Norman Gardens Primary & Junior High	313534	1988825	532	100	19.0
Ormsby Hall Primary	321666	1988206	138	6	0.26
Port Royal All Age and Infant	304812	1984070	148	30	4.90
Rennock Lodge All Age	315078	1987809	1030	307	71.4
Rollington Town Primary	313045	1988553	399	73	22.0
St. Aloysius Primary	310413	1988050	455	24	5.24
St. Anne's Primary	309646	1988545	407	40	5.53
St. George's College	311035	1988502	496	32	6.34
St. George's Girls Primary and Infant	310428	1988162	514	27	5.23
St. Michael's Infant	311506	1987484	297	28	6.36
Tivoli Gardens High	308839	1988456	397	46	8.44

	Zone 18		Highest Predicted		Predicted
Receptor Name	**UTM_E (m)**	**UTM_N (m)**	**1h Average (µg m^{-3})**	**24h Average (µg m^{-3})**	**Annual Average (µg m^{-3})**
Vauxhall High	312144	1987888	302	47	8.88
Windward Road Primary & Junior High	313724	1988229	347	99	27.9
Wolmer's Boys School	310702	1989616	2009	100	12.9
Wolmer's High School for Girls	310787	1989560	2128	120	12.9
Ardenne High	311048	1992459	3397	216	9.23
August Town Primary	316116	1989861	3087	141	5.46
Balmagie Primary	304228	1993549	371	66	6.70
Bito All Age and Infant	323693	1986874	222	10	0.29
Calabar High	308533	1994347	1132	61	5.01
Campion College	312548	1993200	1845	99	4.10
Charlie Smith High	309161	1989834	415	41	9.72
Cockburn Gardens Primary & Junior High	306914	1991113	322	44	9.47
Constant Spring Primary & Junior High	309739	1996182	1959	88	3.12
Constitution Hill All Age	317863	1992808	77	6	0.56
Content Gap All Age	321291	1996084	69	3	0.21
Craighton All Age	317853	1997107	93	7	0.37
Dallas Primary & Junior High	319340	1990739	140	6	0.52
Donald Quarrie High	318182	1985193	161	23	4.25
Drews Avenue Primary and Infant	305219	1993979	401	40	4.63
Duhaney Park Primary	304632	1994635	423	40	4.21
Dupont Primary and Infant	306731	1991225	307	48	9.78
Edith Dalton James High	304472	1994653	436	39	4.25
Edna Manley College of the Visual and Performing Arts	311344	1990902	1737	110	10.2
Excelsior Community College	312750	1990420	1984	133	9.12
Excelsior High	312750	1990420	1984	133	9.12
Friendship Brook All Age	321511	1986032	594	33	1.01
Gaynstead High	311517	1991189	2790	160	11.4
George Headley Primary	304265	1994791	432	35	4.17
Gordon Town All Age	318149	1994874	85	8	0.59
Greenwich All Age	308107	1989619	303	64	11.7
Grove Primary	316635	1994257	118	9	0.68
Haile Selassie High	307352	1990806	268	43	9.65
Harbour View Primary	317797	1985968	194	30	4.49
Holy Childhood High	309538	1992128	931	66	7.06
Hope Valley Experimental Primary &	315812	1991408	801	38	2.13

	Zone 18		Highest Predicted		Predicted
Receptor Name	**UTM_E (m)**	**UTM_N (m)**	**1h Average (µg m^{-3})**	**24h Average (µg m^{-3})**	**Annual Average (µg m^{-3})**
Infant					
Immaculate Conception High	310238	1996018	2415	107	4.46
Iris Gelley Primary	309346	1989837	498	45	9.74
Jack's Hill All Age	313967	1996700	83	8	0.72
Jamaica College	314058	1993190	715	40	2.00
Jones Town Primary	309518	1989474	422	38	8.51
Maxfield Park Primary	308608	1991171	657	82	9.38
Meadowbrook High	307925	1996508	1430	89	4.73
Melrose Primary & Junior High	309293	1990975	751	72	8.88
Merl Grove High	309625	1993771	1321	93	5.74
Mico Practising Primary & Junior High	310702	1989778	2009	100	12.9
Mico Teachers' College	310702	1989778	2009	100	12.9
Mona Heights Primary	314796	1992279	793	37	1.81
Mona High	313940	1992483	742	42	2.45
Mount Fletcher Primary	324420	1993949	88	5	0.21
Papine High	315639	1993554	410	19	1.08
Pembroke Hall High	306080	1994251	253	26	4.23
Priory High	310746	1992994	2629	161	8.10
Red Hills All Age	304163	1997207	134	9	1.58
Richmond Park Primary	308701	1991150	638	79	9.37
Rousseau Primary	308852	1991407	1032	63	8.26
Shortwood Teachers' College	311166	1996229	418	30	1.66
St. Andrew High	309976	1992155	1834	135	7.96
St. Andrew Technical High	308244	1989135	397	85	13.2
St. Francis Primary & Infant School	311487	1991407	3279	168	12.4
St. Hugh's High	311024	1990060	1974	97	11.8
St. Hugh's Prep	311250	1990016	1849	101	12.2
St. Jude's Primary	306352	1993454	271	29	4.98
St. Richard's Primary	308104	1995502	1617	138	6.06
Tarrant High	308979	1992599	1518	78	7.18
The Queens School	309749	1994664	4157	190	8.17
Trench Town High	309132	1989791	377	41	9.55
Trench Town Primary	308964	1989644	225	40	8.84
University of Technology	315390	1993077	706	32	1.25
University of the West Indies	315043	1991713	1688	74	2.43
Whitfield All Age	308322	1990022	300	49	10.4
Bridgeport High	301116	1986428	158	18	2.92

	Zoom 18		Highest Predicted		Predicted
Receptor Name	UTM_E (m)	UTM_N (m)	1h Average (μg m^{-3})	24h Average (μg m^{-3})	Annual Average (μg m^{-3})
Bridgeport Primary	300711	1986731	171	18	2.85
Cumberland High	300670	1988600	212	24	3.08
Edgewater	300730	1986748	171	18	2.87
Greater Portmore High	298590	1983672	147	17	1.71
Gregory Park Primary	300843	1990834	260	43	5.92
Independence City Primary	301623	1989371	206	25	3.55
Naggo Head Infant/Primary	300091	1987030	181	16	2.67
Port Henderson Primary	300271	1989542	190	20	2.73
Portsmouth Primary	302676	1989053	219	31	4.57
Scarborough Primary	301221	1988898	223	25	3.35
Waterford High	302456	1989528	209	31	4.64
Waterford Infant	301686	1990326	262	41	5.99
Waterford Primary	301686	1990326	262	41	5.99
Andrews Memorial Hospital	310654	1992701	3104	171	8.68
Bellevue Hospital	312700	1987947	304	71	12.5
Bustamante Children’s Hospital	311774	1991094	2841	147	11.8
Hope Institute	315628	1991613	761	33	1.98
Kingston Public Hospital	309872	1988415	497	33	5.34
Medical Associates	310023	1991832	1310	90	7.71
National Chest Hospital	313630	1993562	793	43	2.18
Nuttall Memorial Hospital	310927	1990539	1068	63	10.3
Sir John Golding Rehab Centre	315783	1991577	611	29	1.96
St. Josephs	312381	1988873	478	54	16.6
UHWI	315300	1992277	1114	49	1.64
Victoria Jubilee Hospital (VJH)	309881	1988532	438	34	5.35
NEPA 11 Caledonia	310867	1990385	1249	62	10.4
NW1	307271	1988841	522	123	43.3
NW2	306865	1989188	377	175	41.8
NW3	306378	1989646	416	139	30.7
Lab	307542	1988406	456	112	45.4
Smoke Room	307531	1988373	405	130	45.4
Control Room	307552	1988329	396	165	43.3
ADMIN Administrative Building	307541	1988318	400	175	41.7
PUE Processing Unit East	307498	1988263	437	185	37.1
PUW Processing Unit West	307456	1988296	1143	489	72.9
Loading rack/Antilles	307826	1988215	444	162	40.6
BH Boat House	307202	1988343	932	398	88.7

	Zone 18		Highest Predicted		Predicted
Receptor Name	**UTM_E (m)**	**UTM_N (m)**	**1h Average (µg m^{-3})**	**24h Average (µg m^{-3})**	**Annual Average (µg m^{-3})**
Main Gate Guard House	307649	1988538	514	91	38.4
NEPA Cross Roads 10 Caledonia	310804	1990465	969	58	10.4
NEPA 191 Old Hope Road	314172	1993097	454	27	1.78

9.5 HEALTH RISK ASSESSMENT

The Terms of Reference for the EIA include the following item related to health risk assessment:

> *"**Identify** the significant environmental and public health/safety issues of concern and indicate their relative importance. These should include the occupational exposure, health and safety measures and population exposure in the appropriate study areas and changes and or enhancements in emergency response plans."*

The population exposure to chemicals in the emissions from the Petrojam refinery will be assessed by conducting a human health risk assessment. The purpose of the health risk assessment will be to:

c) identify human health risks due to the existing refinery operations, and

d) determine any incremental risks due to the refinery upgrade.

The NRCA *Guideline Document* (NRCA, 2006) suggests that a risk assessment is required for proposed Major Facilities that emit more than 10 tonnes/y of any priority air pollutant (PAP) or more than 25 tonnes/year of any number of PAPs. It should be noted that five of the VOCs that were measured in the ambient VOC monitoring study for the EIA are NRCA Priority Air Pollutants but their annual emissions are each less than 10 tonnes and their combined emissions are also less than 25 tonnes.

The *Guideline Document* also specifies the risk assessment policy which is summarised as follows:

Carcinogens

Negligible risk - Incremental cancer risk ≤one in one million (1×10^{-6}).
Unacceptable risk - Incremental cancer risk ≥ one in ten thousand (1×10^{-4})
If the incremental cancer risk is between one in one million and one in ten thousand, the risk is evaluated on a case-by-case basis.

Non-carcinogens

Hazard quotients are calculated and summed separately for inhalation and oral exposures, and for different averaging times, to give hazard indexes. If the hazard index for any contaminant evaluated is less than or equal to one, the risk is considered negligible.

The first step in the assessment is to identify all chemicals that are released from the refinery and then to select those that are of potential concern for the health risk assessment.

Chemicals are released from the refinery as a result of combustion of fuels (heavy fuel oil, refinery gas and pipe still bottoms), losses from storage of raw materials (e.g., crude oil, MTBE, ethanol) and products (e.g., gasoline, diesel, jet fuel etc.) and from fugitive leaks from equipment (valves, flanges, pumps) and refinery processes (e.g., cooling towers, API separators, drains). These sources and their emissions before and after the upgrade were described and characterised in Section 6.3.1.2. The chemicals released are as follows:

- Oxides of nitrogen, carbon and sulphur (NO, NO_2, CO, CO_2 , SO_2)
- Particulate matter (TSP, PM_{10})
- Volatile organic compounds (VOCs)
- Total Reduced Sulphur compounds (TRS) (H_2S , other organic sulphur compounds)

The next step in the health risk assessment is to identify **chemicals of concern** by comparing measured or modelled concentrations of the chemicals released with regulatory limits and selecting those chemicals that exceed such limits. Chemicals whose measured or predicted concentrations are below their respective limits are not considered to represent a potential concern for human health and are not considered further in the health risk assessment.

The comparisons were based on ambient measurements (for TSP, SO_2, NO_2 and VOCs) or model predictions (CO, SO_2, NO_2, TSP and benzene). While ambient measurements are able to determine the concentrations due to emissions from the existing refinery, dispersion modelling is required to estimate concentrations after the upgrade.

The VOC monitoring undertaken during the EIA measured 18 compounds consisting of two chlorinated compounds that are found in consumer products or used in commercial/industrial products or applications (tetrachloroethylene and trichloroethylene), two compounds emitted from vegetation or used in consumer products (d-limonene and a-pinene) and hydrocarbons associated with gasoline and petroleum refining (n-pentane, 2,2-dimethylbutane, 2-methylhexane, benzene, 2,2,4-trimethylpentane, heptane, 2-methylpentane, toluene, octane, o-xylene, (m+p)-xylene, decane, 1,3-dimethylbenzene and naphthalene).

When both ambient measurements and model predictions are available (TSP, SO_2 and speciated VOCs) it may be possible to compare the two and to indicate approximately how well model predictions compare with measurements. Measurements of ambient concentrations are costly to make at a large number of locations while model predictions can be made at a very large number of locations with little incremental cost. When there are good and consistent comparisons between limited measurements and model predictions the model predictions can be reliably made at a large number of locations. The bases for comparisons of the measurements and/or model predictions for the various pollutants emitted from the Petrojam refinery are indicated in Table 9-3. The last column in the table indicates whether or not the compound will be considered further.

The range for the measured 24 h average concentrations of individual VOCs are given in Table 9-4 (the values in brackets in the leftmost column) together with limits for the compounds in various jurisdictions. The 24 h average concentrations were based on duplicate (and in some cases triplicate badges that were exposed for each location and sampling period. The measured values can be directly compared with the 24 h limits (highlighted text).

Table 9-3 Bases For Comparisons of Benzene Concentrations

Compound	Bases for Comparison	Assessment	Result
TSP	Ambient monitoring Model predictions	Highest measurements well below standard Highest predicted concentrations (existing and after the upgrade) well below 24 h and annual standards	Not of concern. Note ambient monitoring will be conducted anyway.
NO, NO_2	Ambient monitoring (NO_2) Model predictions	Highest measurements are likely to be well below the annual standard and the 1 h Guideline concentration Highest predicted concentrations (existing and after the upgrade) well below the 1 h Guideline concentrations and annual standard	Not of concern. Note ambient monitoring will be conducted anyway.
CO	Model predictions	Predicted concentrations well below ambient standards for both before (existing) and after the upgrade	No
CO_2	None	No ambient standard. CO_2 is not among compounds considered in health risk assessment	No
SO_2	Ambient monitoring Model predictions	Ambient measurements indicate standards are not likely to be exceeded Highest predicted concentrations predictions JNAAQS for the 1 h, 24 h and annual averaging periods are predicted to be exceeded. However, comparisons at monitoring stations indicate model severely overpredicts.	No. However, ongoing continuous monitoring is recommended (and required)
TRS	Estimation of emissions	Upgrade potentially could emit TRS especially when upset conditions occur. Routine emissions considered negligible	Ongoing continuous monitoring is recommended
VOCs	Ambient measurements	See Table 9-4.	

Table 9-4 Comparison of Measured VOCs With Limits in Selected Jurisdictions

Chemical (Measured range for Daily Average Concentration in µg m^{-3})	CAS No.	Concentrations in µg m^{-3}				Jurisdiction (Basis)
		10 min	1 h	24 h	Annual	
Benzene (2 – 531)	71-43-2		 170 1300#	 30	1 4.5 0.13 60	NRCA Texas ESL (H) US EPA ARB (#6hr Avg)
p-Xylene	106-42-3		5750 550	2300	 55	NRCA Texas ESL (H)
Tetrachloroethylene (2.4 – 2.7)	127-18-4		900 2000	360	 26	NRCA, Ontario (H) Texas ESL (H)
Trichloroethylene (2.2 –6.2)	79-01-6		57.5 540	23 12	 2.3 54	NRCA Ontario (H) Texas ESL (H)
Xylenes (2 – 78) o (5 – 227) m+p	1330-20-7	 3000	5750 3700	2300 730	 370 180	NRCA Ontario (O) Ontario (H) Texas ESL (H) Health Canada
1,3-Diethylbenzene (2 – 23)	141-93-5		2500		250	Texas ESL (H)
2,2,4-Trimethylpentane (2 – 12)	540-84-1					
2,2-Dimethylbutane (2)	75-83-2		3500		350	Texas ESL (H)
2-Methylheptane (2 – 50)	107-83-5		3500		350	Texas ESL (H)
2-Methylhexane (2 – 58)	591-76-4		3070		307	Texas ESL (H)
α –Pinene (2)	80-56-8		60		6	Texas ESL (O)
Decane (3)	128-15-5		60,000 10,000		 1,000	Ontario (H& O) Texas ESL (H)
d-Limonene (3)	5989-27-5		1100		110	Texas ESL (H)
Heptane (2 – 62)	142-82-5		 3,500	11,000	 350	Ontario (H) Texas ESL (H)
Naphthalene (2 – 10)	91-20-3	50	 440	22.5	 44	Ontario (H) Texas ESL (H)
n-pentane (4 – 115)	109-66-0		3500		350	Texas ESL (H)
Octane (2 – 26)	111-65-9	61,800	 3500		 350	Ontario (O) Texas ESL (H)
Toluene (6 – 248)	108-88-3		 640	2,000	 1200 3800	Ontario (O) Texas ESL (H) Health Canada

H - Health; O - Other

When it is required to estimate concentrations at (longer) averaging times different from when measurements are made, the following relationship (Equation 9-1) is used.

$$C_s = C_k \left(\frac{t_k}{t_s}\right)^p \qquad \text{9-1}$$

Where

C_s = concentration for (the longer) averaging period s
C_k= concentration for averaging period k
t_k = averaging period k
t_s = averaging period s
p = an exponent in the range 0.17 to 0.75. The recommended value is 0.17.

Based on this relationship, the annual measurements would be ~0.37 times the daily averages and hence the daily measurements in Table 9-4Table 9-4 also can be compared with the annual limits (after applying a factor of 0.37 to the daily measurements). Except for benzene, the measured concentrations of all VOCs are well below any of the corresponding daily or annual limits.

The risk assessment will therefore be limited to benzene.

Dispersion modelling of the benzene sources was used in order to estimate the exposure at a number of receptors. The model predictions for the existing situation can be compared with the ambient benzene measurements that were made during the EIA.

9.5.1 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to predict the potential exposure of selected receptors to benzene through various direct (inhalation) and indirect (contact of human receptors with soil, plants, or water bodies on which emitted chemical has been deposited) pathways. The typical exposure pathways are:

- inhalation;
- the ingestion of soil;
- ingestion of locally grown vegetation;
- ingestion of breast milk; and
- dermal exposures to soil and dust.

Benzene exposures at sensitive receptors were estimated by modelling the worst case emissions from the existing sources. Benzene emission rates for all combustion point sources in the airshed before and after the upgrade are given in Table 9-5 and benzene emissions from tanks and the loading rack before and after the upgrade are given in Table 9-6. Worst case emission rates from combustion sources were made based on the maximum fuel use and maximum clinker production for cement kilns and AP42 emission factors (US EPA, 2008).

Table 9-5 Benzene Emissions From Existing Point Sources in the Kingston Airshed

Source	Stack ID	Benzene Emissions g/s
Flare	FLR	0
Pipestill heater	F1	0.0001
Powerformer Feed preheater F-234	F234	0
Powerformer Feed preheater F-2	PJAMF-234	0
No.1 reheat coils F-3	PJAMF-234	0
No 2 Reheat coil F-4	PJAMF-234	0
Vacuum furnace	F201	0
Nebraska (Oil)	NBRSKA	8.78E-05
New Cleaver Brooks Boiler (B1B)	NCLVRBB	3.99E-05
Hurst Boiler	F1	1.99E-05
D&G Boiler Stack East	DG1	2.29E-05
D&G Boiler Stack West	DG3	1.6E-05
D&G Boiler Stack	DG2	1.6E-05
D&G Grain handling	DGV	0
D&G Brew kettle	DGV	0
JPPC Engine 1	JPPC1	0
JPPC Engine 2	JPPC1	0
CCC Kiln 4 Dry 1300 tons/d	CCCLD	0.011403
CCC Kiln 3 Wet 700 tons/d	CC3	0.058852
JPSCo-Rockfort	JPSROCK	0
JPSCo-Rockfort	JPSR2	0
JPSCo-Hunts Bay B6	JPHB6	0.00084
JPSCo Hunts Bay GT (GT10)	JPHGT10	0.000769
Jamaica Ethanol Processing Ltd.	Jeth 1	3.51E-05
Carib Products	CP1	1.83E-05
JPSCo Hunts Bay GT (A5)	JPHGTA5	0.000509
Flare (New)	FLR	0
Clinker cooler 3	CCLR3	0
Clinker cooler 4	CCLR4	0
D&G Cyclone	DG4	0
New Petrojam Sources		
Sulphur C	45-ME-01*	0
DHT (RFG)	22-F-01	0
CCR (FRG)	31-F-04*	0
NHT (RFG)	21-F-01	0
DCU (RFG)	13-F-01	0

Source	**Stack ID**	**Benzene Emissions g/s**
VDU (RFG startup only)	11-F-01**	0
CDU (RFG Startup only)	01-F-05**	0
VDU (HFO)	11-F-01	0.000135
CDU (HFO)	01-F-05	0.000112
H2 Plant	25-F-01†	0
Utility Boiler 650#	BNew-650#	0.000167
DCU 2 Oil	23-F-01	2.79E-06
Flare New	FLARE	0
Utility Boiler B2 (HFO) NCBB	B2-125#	3.99E-05
Utility Boiler B3 (HFO) Nebraska	B3-125#	8.78E-05
Utility Boiler B1 (HFO)	B1-125#	1.9E-05
DCU 2 RFG	23-F-01	0
Total point source emissions before upgrade		**0.0727**
Total point source emissions after upgrade		**0.0730**

Table 9-6 Benzene Emissions From Petrojam Tank And Loading rack Sources

		Benzene	
CONTENTS	**USERID**	**g/s**	**g/s/m²**
Residual oil no. 6 (EFR)	101	0	0
Crude oil (RVP 5) (EFR)	102	1.86E-03	4.22E-07
Crude oil (RVP 5) (EFR)	103	1.86E-03	4.22E-07
Gasoline (RVP 10) (EFR)	104	5.62E-03	4.01E-06
Gasoline (RVP 10) (EFR)	105	5.34E-03	3.81E-06
Jet kerosene (VFR)	106	2.78E-05	0.00E+00
Gasoline (RVP 10) (EFR)	107	4.92E-03	5.40E-06
Methyl-tert-butyl ether (MTBE) (IFR)	108	0.00E+00	
Jet kerosene (VFR)	109	2.57E-04	
Distillate fuel oil no. 2 (VFR)	110	1.25E-04	
Residual oil no. 6 (VFR)	111	0.00E+00	
Residual oil no. 6 (VFR)	112	0.00E+00	
Residual oil no. 6 (VFR)	113	0.00E+00	
Distillate fuel oil no. 2 (VFR)	114	2.18E-06	
Residual oil no. 6 (VFR)	116	0.00E+00	
Crude oil (RVP 5) (EFR)	118	2.55E-03	2.67E-07
Gasoline (RVP 10) (EFR)	119	4.37E-03	7.20E-06
Residual oil no. 6 (VFR)	120	0.00E+00	
Gasoline (RVP 10)(IFR)	121	4.94E-04	2.28E-07
Asphalt (VFR)	201	0.00E+00	
Asphalt (VFR)	202	0.00E+00	
Asphalt (VFR)	200	0.00E+00	
Asphalt (VFR)	203	0.00E+00	
Distillate fuel oil no. 2 (VFR)	210	1.85E-05	
Jet kerosene (VFR)	LR03	3.55E-05	
Gasoline (RVP 10) (IFR)	LR04	4.71E-04	1.46E-06
Gasoline (RVP 10) (IFR)	LR05	6.55E-04	7.98E-07
Jet kerosene (VFR)	LR06	4.38E-05	
Distillate fuel oil no. 2 (VFR)	LR07	6.12E-06	
Methyl-tert-butyl ether (MTBE) (VFR)	LR08	0.00E+00	
Distillate fuel oil no. 2 (VFR)	LR09	2.67E-05	
Gasoline (RVP 10) (IFR)	LR10	6.85E-04	5.99E-07
Gasoline (RVP 10) (EFR)	LR11	5.48E-03	4.21E-06
Residual oil no. 6 (VFR)	LR12	0.00E+00	
Hydrous ethanol (VFR)	100	0.00E+00	
Anhydrous ethanol (VFR)	400-D1	0.00E+00	
Anhydrous ethanol (VFR)	400-D2	0.00E+00	
Anhydrous ethanol (VFR)	400-M	0.00E+00	

		Benzene	
CONTENTS	**USERID**	**g/s**	**g/s/m^2**
Anhydrous ethanol (VFR)	400-S	0.00E+00	0.00E+00
VGO/CGO [Residual oil no. 6] (EFR)	101U	4.53E-06	1.02E-09
VGO/CGO [Residual oil no. 6] (EFR)	102U	4.53E-06	1.02E-09
Crude oil (RVP 5) (EFR)	103U	1.88E-03	4.26E-07
Crude oil (RVP 5) (EFR)	118U	2.55E-03	2.67E-07
CCR feed [Distillate fuel oil no. 2] (EFR)	122U	2.27E-06	3.74E-09
Diesel intermediate [Distillate fuel oil no. 2] (VFR)	123U	1.72E-05	0.00E+00
Crude oil (RVP 5) (EFR)	124U	1.87E-03	8.60E-07
Sour water (VFR)	125U	0.00E+00	0.00E+00
Gasoline (RVP 11) (IFR)	LR04UE	4.71E-04	7.18E-07
Gasoline (RVP 11) (IFR)	LR05UE	6.55E-04	2.03E-06
Gasoline (RVP 11) (IFR)	LR105UE	6.87E-04	8.37E-07
Gasoline (RVP 11) (IFR)	LR10UE	6.85E-04	1.05E-06
Gasoline (RVP 11) (EFR)	LR11UE	5.48E-03	1.70E-05
Gasoline (RVP 11) (EFR)	104UE	5.62E-03	4.92E-06
Gasoline (RVP 11) (EFR)	107UE	4.92E-03	4.30E-06
Gasoline (RVP 11) (EFR)	119UE	4.37E-03	3.35E-06
Gasoline (RVP 11) (IFR)	121UE	4.94E-04	9.41E-07
Total Tank Emissions Before Upgrade		3.49E-02	2.88E-05
Total Tank Emissions After Upgrade		3.49E-02	2.93E-05
Total Tank Emissions After Upgrade (all E10 Gasoline, no MTBE)		3.03E-02	3.67E-05
Sum of EFR tank sources		3.43E-02	
Sum of all tank sources		3.49E-02	
Loading rack			
Loading rack Truck (gasoline)		0.2787	
Ship loading (gasoline)		8.18E-03	
Total loading		0.2869	1.86E-04
TOTAL EMMISSIONS ALL EXISTING SOURCES		**1.42E-01**	

There are no benzene emission factors for heaters using refinery gas or from the flare since benzene emissions from these sources are negligible. Benzene emissions from the Petrojam's F1 furnace which uses pipestill bottoms were estimated based on the emission factor for heavy fuel oil since there is no benzene emission factor for pipestill bottoms and the fuel characteristics for heavy fuel oil and pipestill bottoms are not too dissimilar.

Estimates of VOC emissions from equipment in the processing area (from valves, flanges, compressor seals drains et.) of refineries are typically estimated based on the numbers of pieces of equipment and corresponding emission factors. When data on the number of pieces of equipment are not known (as is the case with the Petrojam refinery) estimates may be made by scaling the emissions for a typical refinery (viz., 330,000 bbl/d) to that for Petrojam (36,000 bbl/d). Such scaling introduces considerable uncertainty since the Petrojam refinery is not as complex (fewer processes) as the typical refinery and hence has fewer pieces of equipment and processes. Emissions from the API separator are the largest single source of VOC emissions and in order to reduce the uncertainty, the emissions from oil water separator were based on Petrojam's waste water flow (instead of the emissions based on scaling). The estimated VOC emissions range from 324 tonne/y (when Petrojam-specific data used for the emissions from the API separator) to 734 tonne/y using scaling data alone. Benzene emissions are estimated based on the typical benzene content of various streams. Data for estimating benzene emissions from the existing processing area are given in Table 9-7 and Table 9-8.

It is not feasible to estimate the emissions from the new processing unit but it is reasonable to assume that because of newer technology and an advanced wastewater treatment plant, that the emissions from the new wastewater plant and the remainder of the processing units would not be greater than that from the existing one and in fact could be considerably less.

The maximum benzene emission rates from the loading rack were based on dividing the annual emissions by the hours when loading operations take place (of 5 days/week and 12 hours per day or 3,120 hours operation per year).

Storage tank emissions were estimated using the US EPA Tanks software and took into account the physical properties of tanks (colour, condition, dimensions etc.) and the annual throughput of material in each tank. Benzene emission rates from storage tanks and the loading rack arise mostly from the gasoline storage or loading. The gasoline storage tanks are mainly external floating roof tanks whose emissions are mostly from rim losses and hence do not depend much on periods when tanks are being filled. The maximum emission rates from tanks were therefore based on emissions throughout all hours of the year.

Table 9-7 Data For Estimating Processing Area Emissions

		330000 bbl/d	36000 bbl/d		
		VOC Emissions			Benzene Emissions
Source	**Number**	**kg/day**	**tonne/y**	**g/s**	**g/s**
Valves	11,500	3,100	111	3.52	0.00352
Flanges	46,500	300	11	0.341	0.00034
Pump seals	350	590	21	0.670	0.00335
Compressor seals	70	500	18	0.568	0.00284
Relief valves	100	200	7	0.227	0.00023
Drains	1	450	16	0.511	0.0123
Cooling towers	1	730	26	0.830	0.00000
Oil/Water separators*	1	14600	132	16.6	0.398
TOTAL	—	20,470	342	23.3	0.421

Emissions based on uncontrolled emission factor (0.6 kg VOC/10^3 L waste water and annual flow 220x 10^6 L/y)

Table 9-8 Profile Data For Estimating Processing Area Emissions

Species profiles	Profile #	Benzene (%)
Covered drainage/Separation pits	0031	2.4
Pipe valve flanges	0316	0.1
Pump seals composite	0321	0.5
Area of Processing Unit (as modelled)	1552.5	m^2

The emission rates for the loading rack and tanks depend on the weight percentage of benzene in gasoline vapour. The default value used in the US EPA profiles is 1.8% benzene (by weight) for tanks but this is just over two times greater than that calculated (0.79% benzene by weight) from the mean benzene content of gasoline (1.83% by volume (Petrojam, 2009)) loaded or stored by Petrojam. Use of the default profile will therefore be conservative (high).

The benzene emission rate from all existing combustion sources (0.00247 g/s) is much smaller than that from the tanks (0.0342 g/s), the loading rack (0.107 g/s) and the refinery processing unit (0.123 g/s). Benzene emissions from tanks and the loading rack (Table 9-6) were similar before and after the upgrade. Note that although the capacity of the refinery will be increased, the throughput of products (especially gasoline) will be the same since the current level of imports will be replaced by production and hence the total throughput of gasoline will not change. Because of this the emissions from loading and tank storage would not change. Emission estimates were also made assuming MTBE is replaced by ethanol and this scenario did not result in any significant change in the total emissions from storage tanks.

Since the benzene emissions from loading rack and tanks are essentially the same before and after the upgrade, the benzene concentrations due to these sources will not change because of the upgrade. Because of the negligible contributions of combustion sources and the similarity of benzene emissions from tanks and the loading operation before and after the upgrade, the dispersion modelling was limited to the existing case.

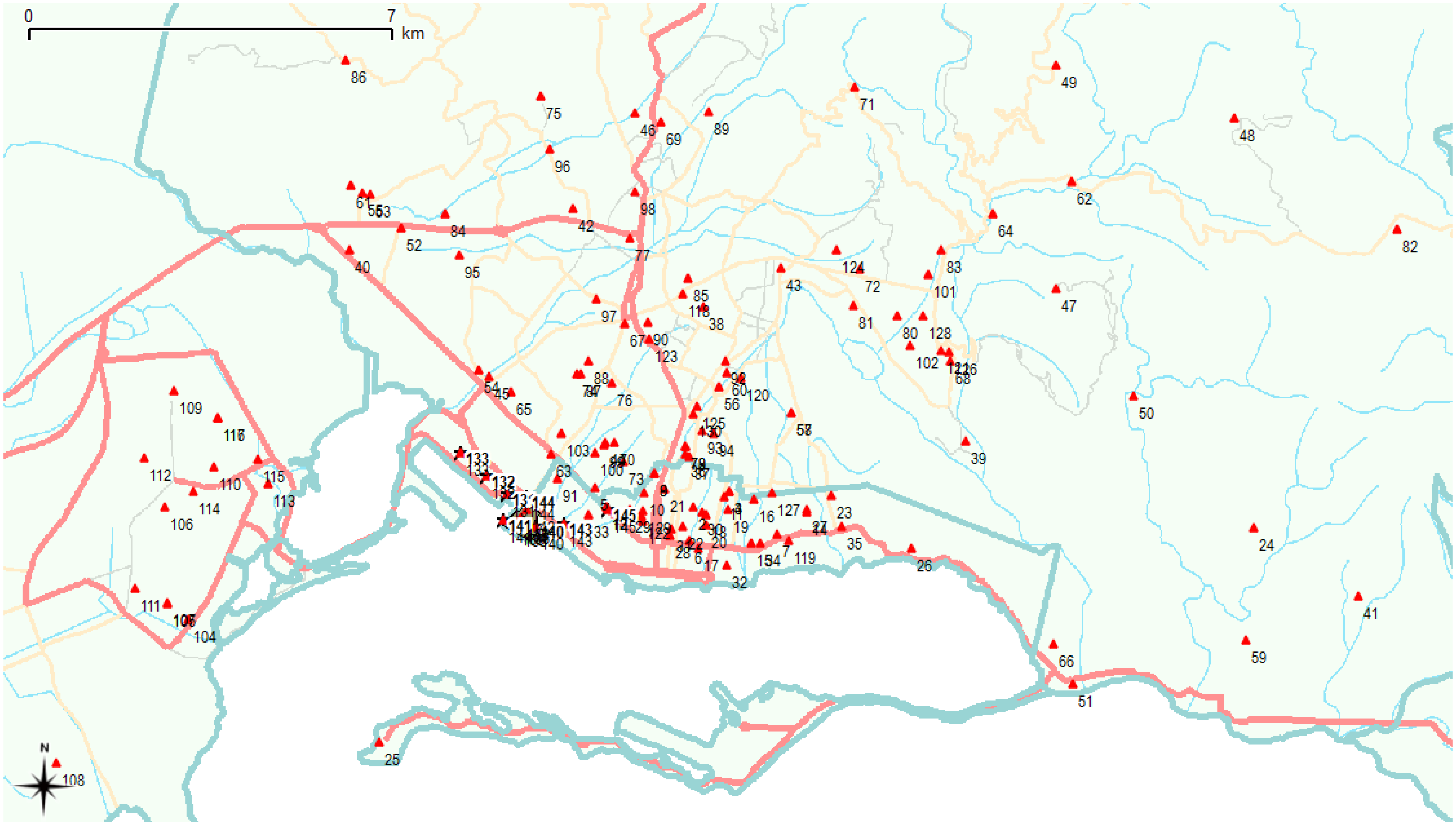
Emission rates of benzene from all sources in the model domain were used in the dispersion model. The modelling used the same meteorological, surface and receptor data as was used in the modelling of SO_2, NOx, TSP and CO. For the exposure assessment, model predictions were made at a number of sensitive receptors (see Figure 9-1). The *Guideline Document* suggests that these receptors be places such as schools, hospitals and health clinics. The receptors included 12 hospitals or health clinics and 117 schools/educational institutions and the monitoring stations at which VOCs were measured. It should be noted that one of these monitoring stations (the loading rack (LR)) is on Petrojam's property. The nearest residence to the east is east of an infant School so that school (St. Michael's Infant) is used instead.

Model predictions for the highest 1hr, 24 hr and annual benzene concentrations due to all sources and various source groups are summarised in Table 9-9 which indicates that:

- Petrojam (Petrojam Point) and other point sources in the model domain (Non-Petrojam Point) contribute negligible amounts to the highest predicted concentrations
- The processing area and the loading rack sources are by far the greatest contributors (over 99.9%) to the highest predicted benzene concentrations.
- Petrojam point sources make a negligible contribution to the predicted ambient benzene concentrations

The contours showing the locations of the highest predicted 6 hr, 24 hr and annual benzene concentrations due to all sources are shown in Figures 9-2, 9-3 and 9-4 respectively. The outermost contour line in each figure represents the limit for the averaging period and hence areas within the outermost contour have predicted benzene concentrations that are predicted to exceed the limit. The plots for the highest 1h, 24 h and annual average benzene concentrations due to the Petrojam loading rack sources (see Figures 9-5, 9-6 and 9-7 respectively) are essentially identical to those for all sources. That is the loading rack sources are the dominant source that contribute to the highest predicted concentrations.

Figure 9-1 Map Showing the Location of Special Receptors



See Table 9-13 for key to the names of the receptors.

Table 9-9 Model Predictions for Benzene

Source Group	Emission Rate (g/s)	Averaging Period	Ambient Air Quality Standard (μg m $^{-3}$)	Max Predicted Conc. (μg m $^{-3}$)	Location			
					UTM E (m)	UTM N (m)	Distance #	Direction # (º from North)
Petrojam Point	0.000248	1 h	170	0.0199	309200	1988605	1.7	78
		24 h	30	0.00429	306600	1988400	0.9	279
		Annual	1	0.00028	306500	1988400	1.0	278
Petrojam Tanks	0.0349	1 h	54	4.79	307800	1989800	1.6	11
		24 h	30	0.449	308000	1988200	0.5	96
		Annual	1	0.132	307968	1988312	0.5	83
Petrojam Loading	0.107	1 h	170	6302	307912	1988280	0.4	87
		24 h	30	895	307912	1988280	0.4	87
		Annual	1	208	307912	1988280	0.4	87
Petrojam Processing Area		1 h	170	591	307497.94	1988262.75	**	**
		24 h	30	271	307497.94	1988262.75	**	**
		Annual	1	3.34	307455.56	1988296.25	**	**
Non-Petrojam		1 h	170	0.399	317000	1988000		
		24 h	30	0.0527	316000	1987000		
		Annual	1	0.00566	317000	1986000		
All Sources	0.145	1 h	170	6302	307912	1988280	0.4	87
		24 h	30	895	307912	1988280	0.4	87
		Annual	1	209	307912	1988280	0.4	87

Relative to the Petrojam F1 stack. ** Maximum value occurs within the Petrojam Plant boundary

Figure 9-2 Contours for the Highest Predicted 1 h Average Benzene Concentration Due to All Sources

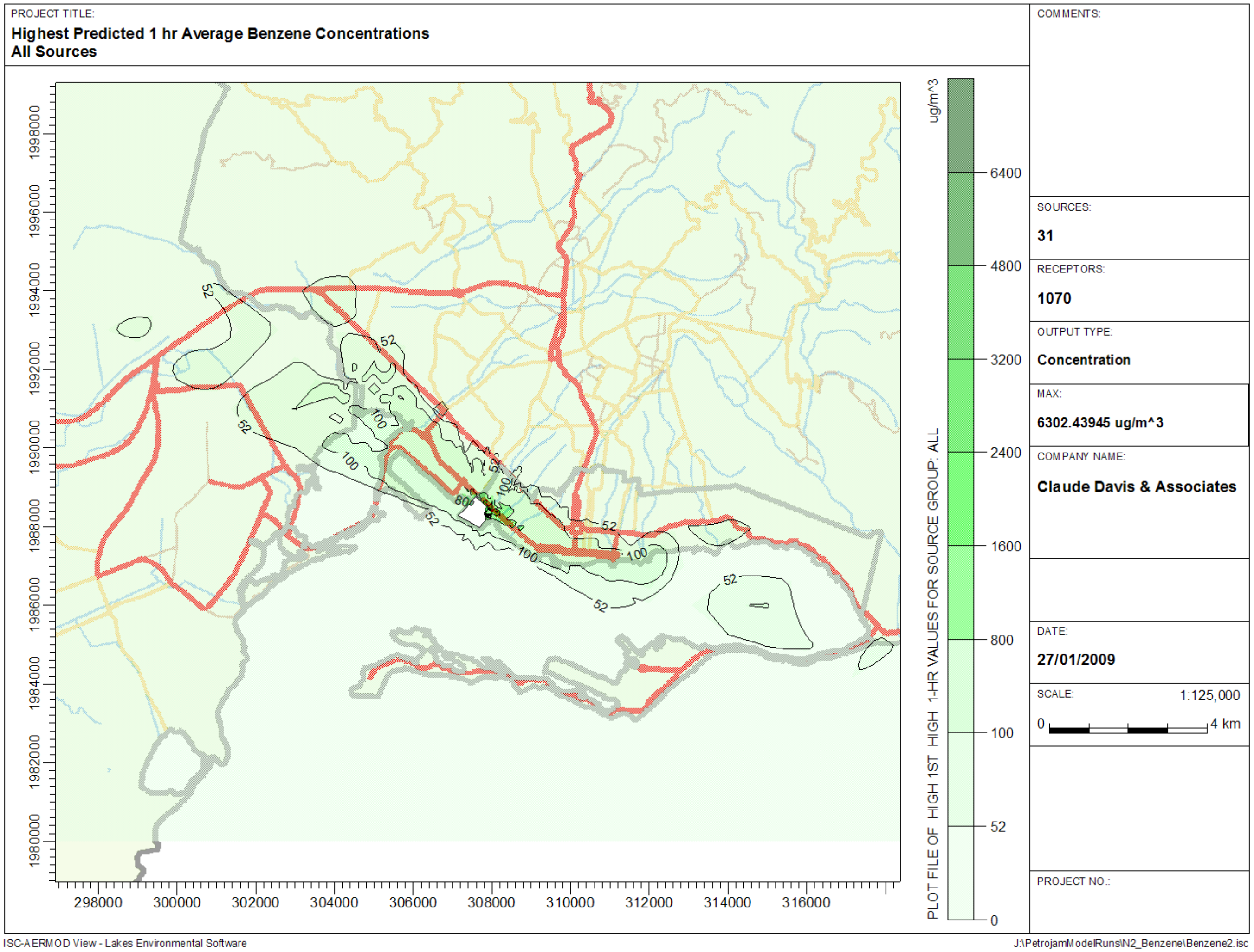


Figure 9-3 Contours for the Highest Predicted 24 h Average Benzene Concentration Due to All Sources

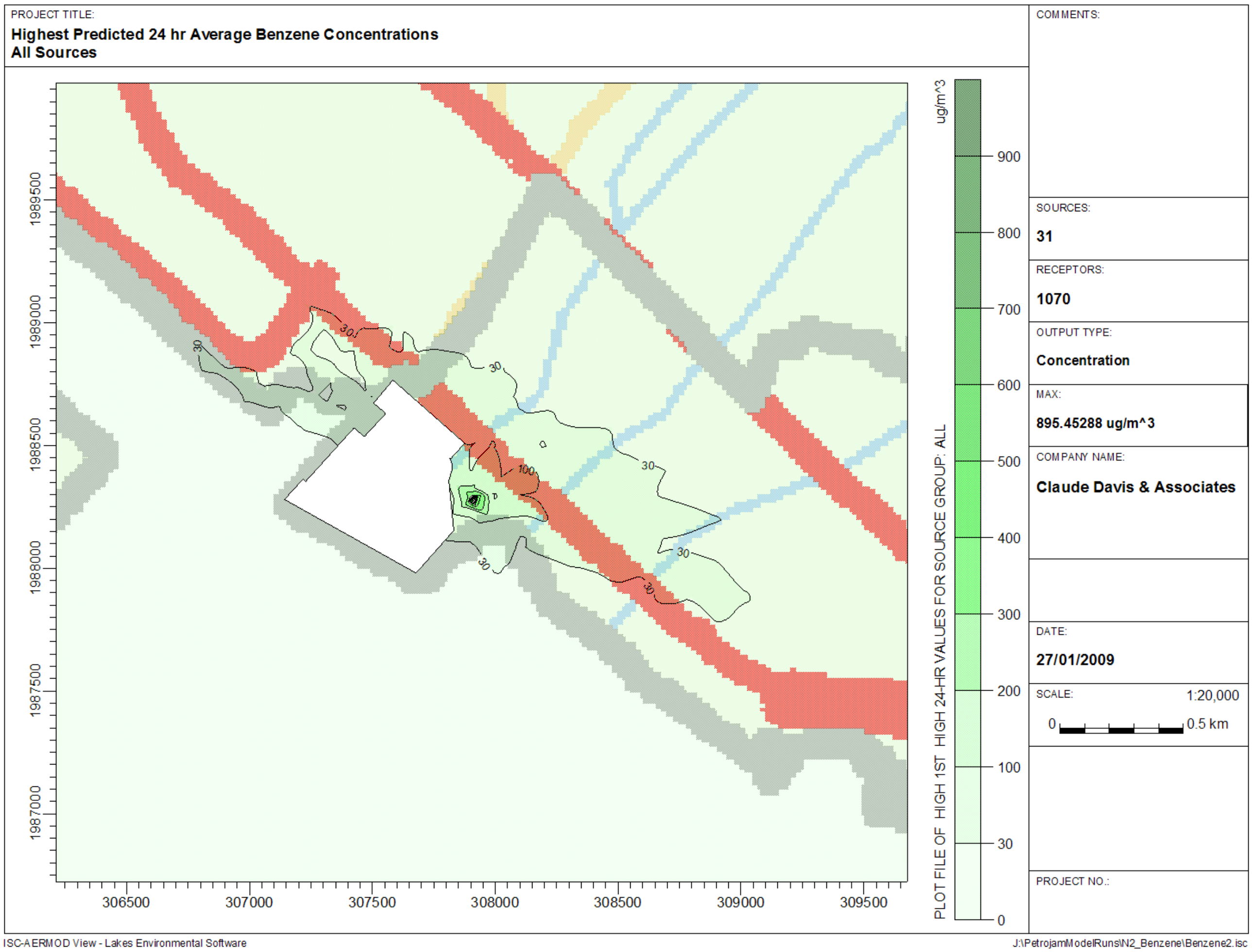


Figure 9-4 Contours for the Highest Predicted Annual Average Benzene Concentration Due to All Sources

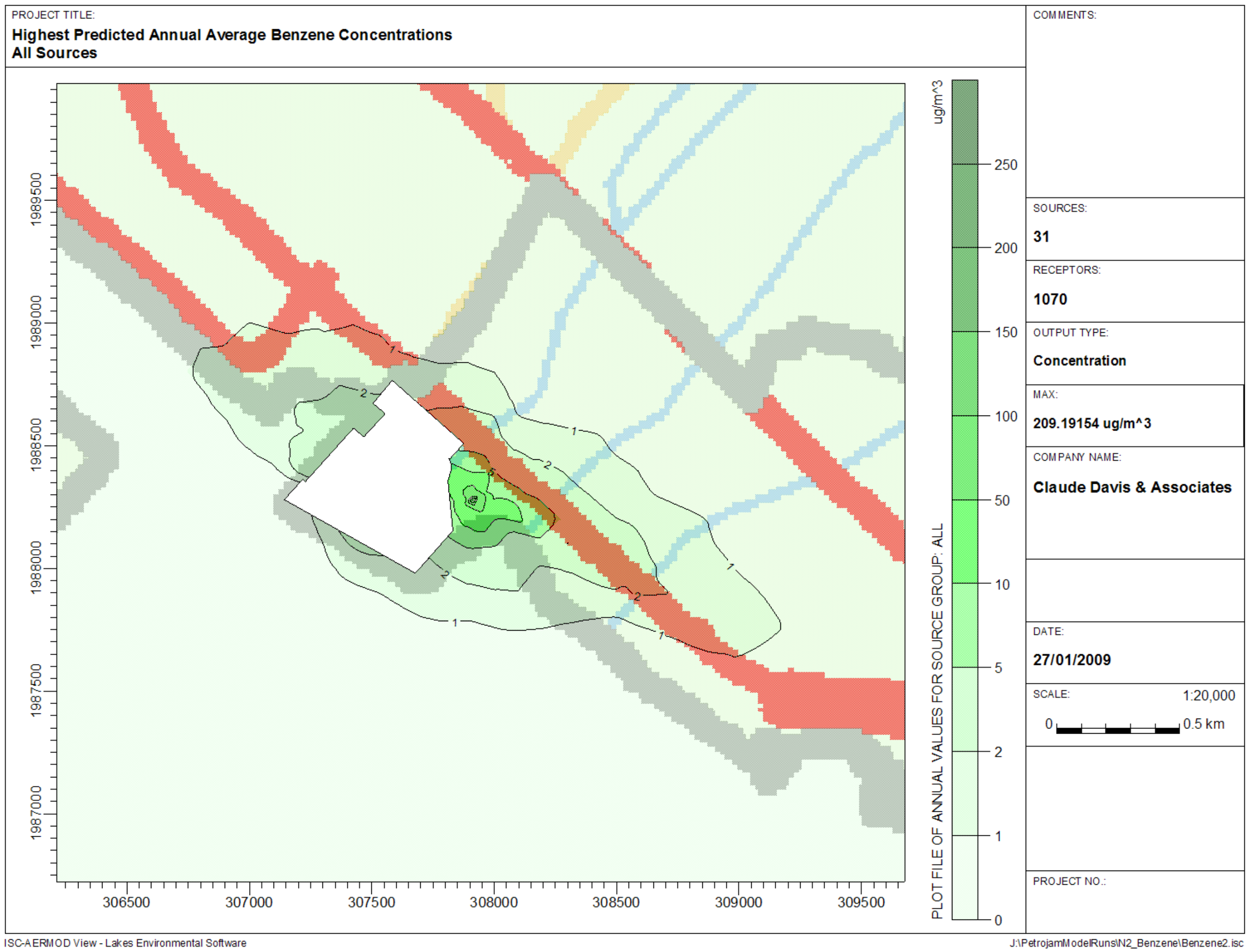


Figure 9-5 Contours for the Highest Predicted 1 h Average Benzene Concentration Due to Loading rack Sources

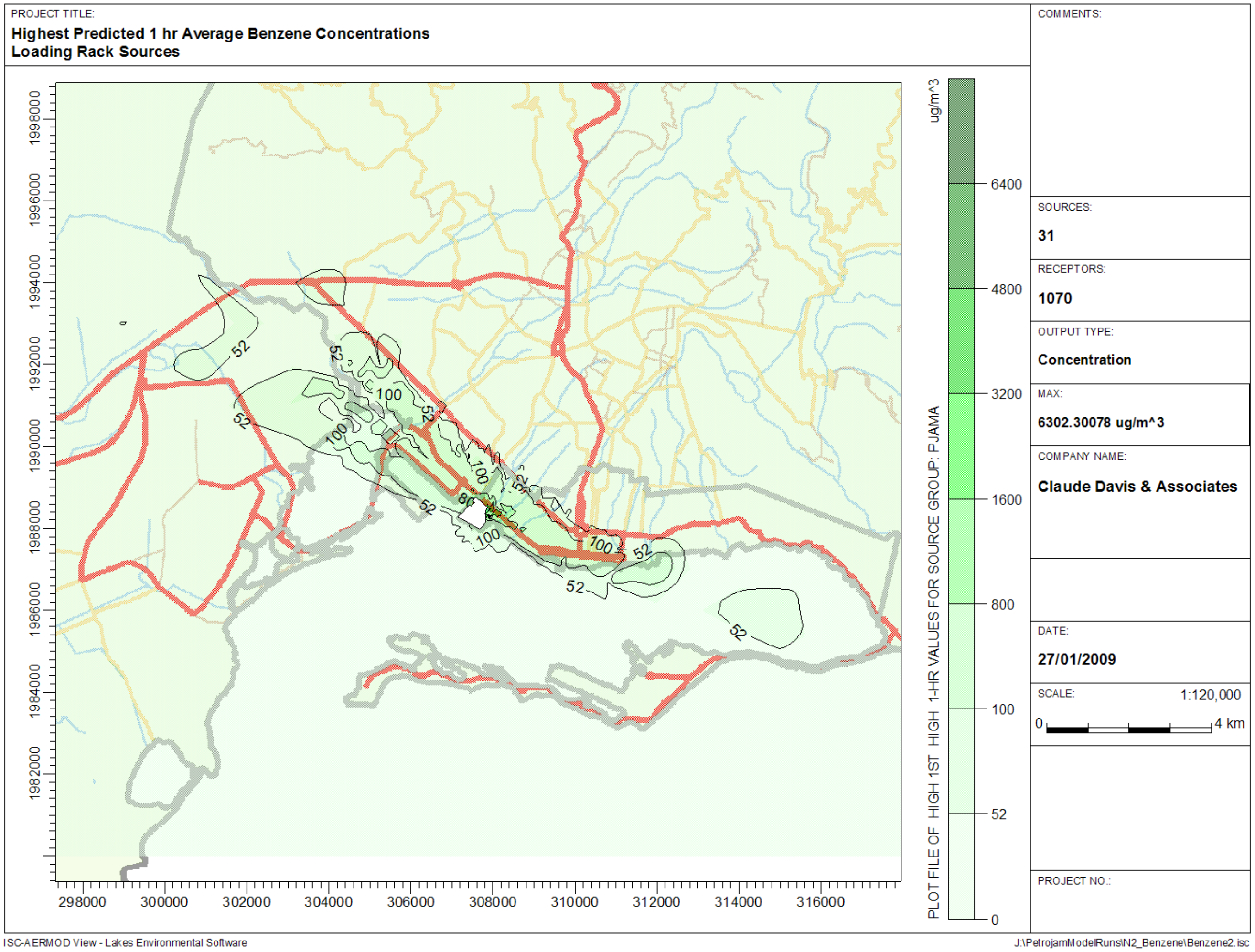


Figure 9-6 Contours for the Highest Predicted 24 h Average Benzene Concentration Due to Loading rack Sources

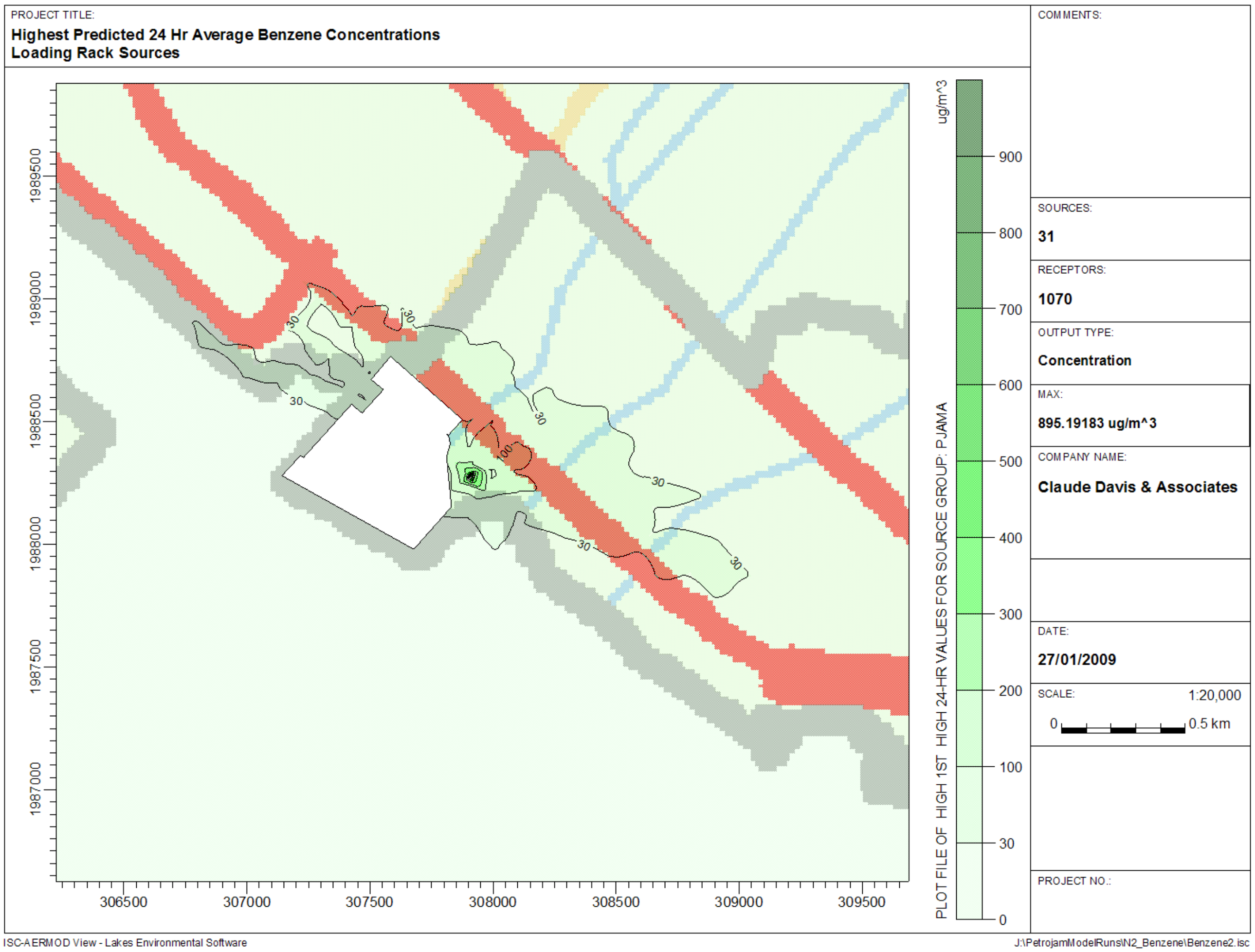
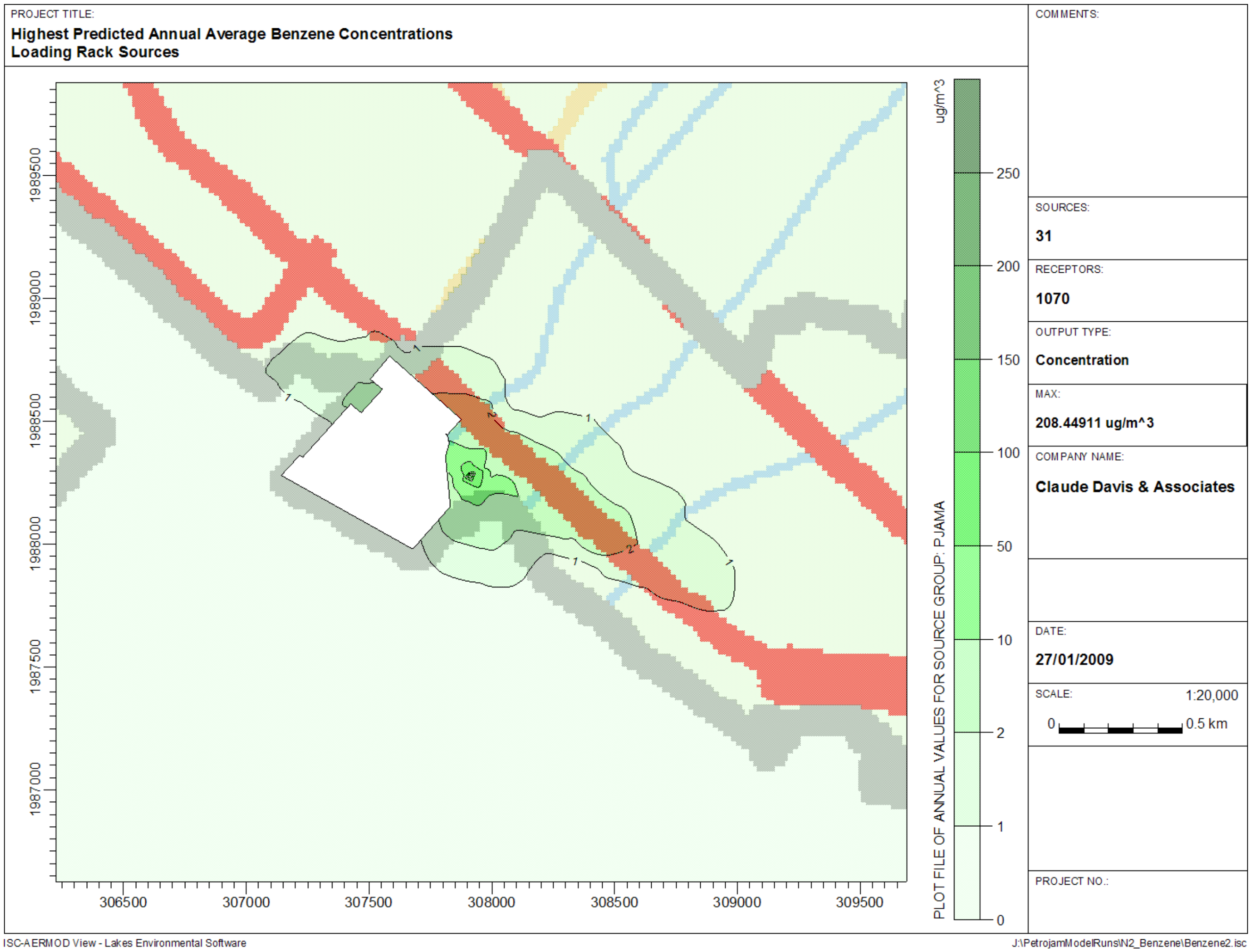


Figure 9-7 Contours for the Highest Predicted Annual Average Benzene Concentration Due to Loading rack Sources



9.5.2 Comparison Between Modelled and Measured Benzene Concentrations

Although daily average ambient measurements made during the EIA were for a limited period, it is instructive to examine more carefully the measured values before comparing the measured values with predictions for the highest 24h (and annual) average concentrations. The highest and the mean measured 24 h benzene concentrations together with the highest predicted benzene concentration at each monitoring station are shown in Table 9-10. Also included in Table 6-7 is the highest measured value when the September 8 values are excluded. The individual daily average measurements are shown in Table 9-11.

Apart from the values on September 8, all but one of the measurements in Table 9-11 are less than the 24 h limit (see Table9-7).

In all cases, the measured mean values were greatly influenced by a single day (September 8 - in all cases) on which high values occurred. Possible explanations for the high values are

a) some event at the refinery on the day in question was responsible for the high values

b) the samples on that day were contaminated by benzene.

Further examination of the data for other compounds show that the ratios of several compounds strongly associated with gasoline (n-pentane, benzene, heptane, toluene, o-xylene, (m+p)-xylene) and other compounds present (2-Methylhexane, 2-methylheptane, 1,3-diethylbenzene) to o-xylene were consistent on all days except on September 8 (see Table 9-12). Similar patterns are shown for example when toluene instead of o-xylene is used for comparing the ratios. A consistent ratio is expected if the same source or sources is (are) present and hence responsible for the measured concentrations. It is unlikely that there was an additional source only on the day when the high measurements occurred and the most likely explanation is that the samples on September 8 were contaminated with benzene.

The comparisons between the measurements and the model predictions in Table 9-10 show that the model predictions are 1 to 4 times greater than the highest measurements (when data for September 8 are excluded). Such comparisons must be viewed with caution because:

- Emission rates used in the model were conservative (high) and have large uncertainties
- Monitoring data were obtained over a limited time period
- Background levels of benzene are not included in model predictions. Emissions from motor vehicle traffic will contribute to the background levels.

It is therefore likely that the model predictions are conservative (high).

The model predictions provide indications of where high concentrations can be expected and in view of the limitations and large uncertainties in the emission rates cited above the predictions at receptors must be viewed with caution. However, because the loading amounts and loading processes will not change with the upgrade there will be no increases in the benzene concentrations. Hence the upgrade will not result in any increased risk due to benzene emissions.

Table 9-10 Maximum and Mean Measured and the Highest Predicted 24 h Average Benzene Concentrations

Location	Max Predicted (µg m^{-3})	Measured Max (µg m^{-3})	Measured Max (Excluding Sep 8) (µg m^{-3})
BH	14.8	531	4.6
NW1	43.2	266	10.5
NW2	23.4	219	7.4
NW3	10.2	144	5.2
LD	86.3	422	79.7

Table 9-11 Measured 24 h Average Benzene Concentrations

	24 h Average Benzene Concentration (µg m^{-3})					
Station	**Sep 8**	**Sep 10**	**Sep 12**	**Sep 15**	**Sep 22**	**Sep 24**
BH	530.8	3.8	2.0	3.3	3.2	4.6
NW1	265.9	10.5	2.0	9.7	3.9	8.6
NW2	219.3	4.2	2.0	6.2	3.3	7.4
NW3	144.0	2.0	2.0	4.6	3.0	5.2
ALD	422.0	79.7	16.5	20.1	29.4	17.1

Table 9-12 Ratios of the Measured 24 h Concentrations of Selected Compounds to o-Xylene

		n-Pentane	2-Methylhexane	Benzene	Heptane	2-Methylheptane	Toluene	(m+p)-Xylene	o-Xylene	1,3-Diethylbenzene
ALD	Sep 8	1.9	0.5	39.4	0.5	0.5	2.3	2.7	1.0	0.3
BH	Sep 8	7.5	1.6	119.4	2.9	2.0	4.6	2.6	1.0	0.5
NW1	Sep 8	3.8	1.0	8.8	0.7	0.5	4.9	3.0	1.0	0.1
NW2	Sep 8	5.5	1.0	77.8	1.2	0.9	5.5	2.7	1.0	0.8
NW3	Sep 8	3.7	1.3	56.6	1.0	1.0	6.7	2.4	1.0	0.9
ALD	Sep 10	1.4	0.7	1.0	0.8	0.6	3.2	2.9	1.0	0.3
BH	Sep 10	5.5	1.4	1.0	1.8	1.3	4.8	2.8	1.0	0.7
NW1	Sep 10	5.9	1.2	2.9	1.1	1.0	5.3	2.4	1.0	0.7
NW2	Sep 10	5.9	1.0	1.7	1.0	1.0	6.4	3.0	1.0	0.9
NW3	Sep 10	3.0	0.9	0.8	0.9	1.0	6.1	2.3	1.0	0.9
ALD	Sep 12	3.2	0.9	0.6	0.5	0.5	3.7	2.9	1.0	0.3
BH	Sep 12	2.6	1.0	0.8	0.9	1.0	4.2	1.9	1.0	0.9
NW1	Sep 12	2.5	0.6	0.5	0.6	0.6	3.9	2.9	1.0	0.6
NW2	Sep 12	1.7	0.9	0.8	0.9	1.0	4.2	2.0	1.0	0.9
NW3	Sep 12	1.5	0.9	0.8	0.9	1.0	4.7	2.2	1.0	0.9
ALD	Sep 15	4.0	1.0	1.4	0.9	0.3	3.4	2.8	1.0	0.2
BH	Sep 15	1.8	1.0	1.4	1.1	1.1	2.8	2.3	1.0	1.0
NW1	Sep 15	21.5	1.3	3.7	1.2	0.9	3.6	2.5	1.0	0.9
NW2	Sep 15	5.0	1.0	2.6	1.1	1.1	3.5	2.2	1.0	1.0
NW3	Sep 15	2.3	0.9	1.8	1.0	1.0	2.9	2.2	1.0	0.9
ALD	Sep 22	5.6	1.2	1.6	1.1	0.4	3.9	3.1	1.0	0.2
BH	Sep 22	3.5	1.1	1.4	1.3	1.1	5.4	2.4	1.0	1.0
NW1	Sep 22	2.5	0.8	1.3	0.9	0.9	4.7	2.6	1.0	0.8
NW2	Sep 22	2.3	0.9	1.3	0.9	1.0	3.8	2.3	1.0	0.9
NW3	Sep 22	2.2	0.9	1.2	0.9	1.0	4.1	2.2	1.0	0.9
ALD	Sep 24	6.8	0.7	2.0	1.3	0.4	4.7	3.1	1.0	0.3
BH	Sep 24	1.9	0.7	1.3	0.8	0.7	5.3	3.1	1.0	0.7
NW1	Sep 24	9.4	1.1	2.4	1.4	0.9	5.8	3.3	1.0	0.7
NW2	Sep 24	3.3	0.9	2.6	1.3	0.9	6.4	3.4	1.0	0.8
NW3	Sep 24	2.6	0.8	1.7	0.9	0.8	5.9	3.3	1.0	0.8

9.5.3 TOXICITY ASSESSMENT

Risks associated with emissions from the refinery were estimated by comparing the exposure rates predicted by the model with established toxicity reference values (TRVs). These TRVs are provided as rates of exposure to which the receptor can be exposed without adverse human health effects. Risks are estimated by directly comparing the project-specific rate of exposure to the TRV. TRVs are established by regulatory agencies (e.g., USEPA, California Air Resources Board, Health Canada or the Ontario Ministry of the Environment) and are based on animal toxicity tests or human epidemiological studies.

Benzene is classified as a Group 1 carcinogen (carcinogenic to humans) by the International Agency for Research on Cancer and a Group A carcinogen (human carcinogen) by the USEPA (US EPA carcinogenicity assessment for benzene accessed online at http://cfpub.gov/ncea/iris/index.cfm) and hence benzene was assessed for both non-carcinogenic and carcinogenic effects.

The TRVs used to assess human health effects were taken from the USEPA's Integrated Risk Information System (IRIS) (US EPA, 2008 http://cfpub.epa.gov/ncea/iris/index.cfm) and the California Air Resources Board (ARB, 2008). The reference concentration (RfC) and inhalation unit risk (IUR) provided on IRIS were used to assess non-carcinogenic and carcinogenic effects, respectively, from inhalation exposure to benzene. The RfCs provided by IRIS are estimates (with uncertainty spanning perhaps an order of magnitude) of daily continuous 24-hour exposure of the human population, including sensitive subpopulations, that is unlikely to cause adverse effects during a lifetime. Since IRIS and ARB provided chronic TRV values, the lower (more stringent) value was used to evaluate the hazard quotient. The chronic exposure assumes lifetime exposure. Acute effects were assessed by comparing the highest predicted 6 hr average benzene concentration to the acute reference value. The TRVs considered are provided in Table 9-13 below.

9.5.4 NON-CANCER RISKS

Dose-response relationships for effects other than cancer are typically expressed in terms of the inhalation reference concentration (RfC). The RfC is a concentration of the compound in air thought to be without adverse non-cancer health effects even if a person is exposed continuously.

To express non-cancer hazards, a hazard quotient (HQ), which is the ratio between the concentration to which a person is exposed and the RfC, is calculated. Regulatory agencies concur that a hazard quotient value below one (1) is not significant – that is no adverse health effects would be expected (USEPA, 1989; Health Canada, 2004). A value of the HQ greater than 1.0 indicates that the exposure is higher than the RfC. However, because many RfCs incorporate protective assumptions in the face of uncertainty, an HQ greater than one does not necessarily suggest a likelihood of adverse effects. A HQ greater than 1.0 can best be described as indicating that a potential exists for adverse health effects.

However, apportionment is typically applied as the percentage of the regulatory-health based level that is allocated to the source/pathway being regulated; that is, 20% of the TRV is allocated for each source of exposure. Typically, it is assumed that people are exposed to contaminants in soil (0.2), groundwater (0.2), air (0.2), food (0.2) and consumer products (0.2) for a total of 100% or 1. An apportionment factor of 0.6 for benzene was used because it may be present in air, soil and groundwater.

The highest predicted 1hr, 6 hr, 24 hr and annual average benzene concentrations at the special receptors together with the HQ for acute (based on the 1 hr prediction) and chronic (based on the 24 h prediction) exposures and the ILCRs (based on annual exposure) for each receptor are presented in Table 9-13. Receptors at which the highest predicted 1 hr, 24 hr and annual average concentrations exceed the corresponding screening limit or reference concentrations are highlighted in yellow.

Table 9-13 Toxicity Reference Values For Benzene

Source	Non-Cancer Effects		Cancer Risk	
	Acute Inhalation ($\mu g\ m^{-3}$)	Chronic Inhalation ($\mu g\ m^{-3}$)	Inhalation Unit Risk# ($\mu g\ m^{-3})^{-1}$	Inhalation Cancer Potency Factor# $(mg/kg\text{-}d)^{-1}$
ARB	1300 (6 hr average)	60	2.9E-05	1.0E-01
IRIS		30	7.8E-06 2.2E-06	

Inhalation cancer potency factor: The “unit risk factor” has been replaced in the new risk assessment algorithms the “inhalation cancer potency factor”. Inhalation cancer potency factors are expressed as units of inverse dose [$(mg/kg\text{-}day)^{-1}$]. They were derived from unit risk factors [units = $(\mu g/m^3)^{-1}$] by assuming that a receptor weighs 70 kg and breathes 20 m^3 of air per day. ARB data available from http://www.oehha.ca.gov/air/hot_spots/index.html
IRIS data available from http://cfpub.epa.gov/ncea/iris/index.cfm

For a 1 hr exposure the ratio of the highest predicted 1 hr concentration to the Texas ESL is greater than 1 for all 6 monitoring stations and the nearest residence to the northwest. The Texas 1 hr Exposure Screening Limit is used to indicate the need for further scrutiny (i.e., by examining the hazard quotients and incremental cancer risks).

As shown in Table 9-14, non-cancer health risks associated with acute (6 hr) exposure to benzene remained significantly below the target HQ of 0.6 for all receptors.

For chronic exposure – based on the highest predicted daily average benzene concentration, five receptors (NW1, NW2, LR, GRMX and the nearest residence to the northwest (NRNW) have hazard quotients greater than 0.6 (see Figure 9-8).

Figure 9-8 Map Showing Locations of Monitoring Stations and Nearest Residences

See Table 9-1 for descriptions of stations

Table 9-14 Model Predictions and Risk Parameters At Special Receptors

		Highest Predicted Concentration (µg m^{-3})				Non-Cancer Acute		Non-Canc Chr	Cancer			
ID	Receptor	1 hr	6 hr	24 hr	Annual	TR_1	HQ_6	HQ_{24}	ILCR	$\%N_{ex}$ (1hr)	$\%N_{ex}$ (6hr)	$\%N_{ex}$ (24hr)
1	All Saints Infant	63	11	2.8	0.066	0.4	0.0	0.1	1.44E-07			
2	Allman Town Primary	22	4	1.0	0.017	0.1	0.0	0.0	3.76E-08			
3	Alpha Infant	17	3	0.9	0.008	0.1	0.0	0.0	1.67E-08			
4	Alpha Primary	17	3	0.9	0.008	0.1	0.0	0.0	1.67E-08			
5	Boys Town All Age	97	16	4.2	0.082	0.6	0.0	0.1	1.79E-07			
6	Calabar Infant Primary & Junior High	64	25	6.3	0.111	0.4	0.0	0.2	2.45E-07			
7	Camperdown High	34	7	1.8	0.027	0.2	0.0	0.1	5.89E-08			
8	Central Branch All Age	10	3	0.8	0.009	0.1	0.0	0.0	1.92E-08			
9	Central Branch Infant	10	3	0.8	0.009	0.1	0.0	0.0	1.92E-08			
10	Chetolah Park Primary	29	6	1.3	0.021	0.2	0.0	0.0	4.52E-08			
11	Convent of Mercy "Alpha"	13	2	0.6	0.008	0.1	0.0	0.0	1.73E-08			
12	Denham Town High	94	19	4.6	0.130	0.6	0.0	0.2	2.85E-07			
13	Denham Town Primary	94	19	4.6	0.130	0.6	0.0	0.2	2.85E-07			
14	Dunoon Park Technical High	23	4	1.1	0.016	0.1	0.0	0.0	3.44E-08			
15	Elletson Primary and Infant	50	18	4.5	0.074	0.3	0.0	0.2	1.63E-07			
16	Franklyn Town Primary	12	2	0.5	0.007	0.1	0.0	0.0	1.45E-08			
17	Holy Family Primary and Infant	62	10	2.6	0.109	0.4	0.0	0.1	2.40E-07			
18	Holy Trinity High	31	9	2.5	0.029	0.2	0.0	0.1	6.30E-08			
19	Jessie Ripoll Primary	31	6	1.6	0.022	0.2	0.0	0.1	4.95E-08			
20	Kingston College	17	4	1.0	0.023	0.1	0.0	0.0	5.15E-08			
21	Kingston High	13	3	0.6	0.011	0.1	0.0	0.0	2.36E-08			
22	Kingston Technical High	23	6	1.5	0.032	0.1	0.0	0.0	7.03E-08			
23	Norman Gardens Primary & Junior High	7	1	0.3	0.007	0.0	0.0	0.0	1.57E-08			
24	Ormsby Hall Primary	0	0	0.0	0.000	0.0	0.0	0.0	4.84E-10			
25	Port Royal All Age and Infant	6	1	0.3	0.013	0.0	0.0	0.0	2.91E-08			
26	Rennock Lodge All Age	35	7	1.8	0.030	0.2	0.0	0.1	6.67E-08			
27	Rollington Town Primary	18	5	1.5	0.016	0.1	0.0	0.0	3.62E-08			
28	St. Aloysius Primary	75	26	6.5	0.115	0.4	0.0	0.2	2.54E-07			
29	St. Anne's Primary	57	11	2.8	0.047	0.3	0.0	0.1	1.04E-07			
30	St. George's College	39	8	2.1	0.029	0.2	0.0	0.1	6.32E-08			
31	St. George's Girls Primary and Infant	61	12	3.2	0.060	0.4	0.0	0.1	1.31E-07			
32	St. Michael's Infant	52	9	2.6	0.122	0.3	0.0	0.1	2.68E-07			
33	Tivoli Gardens High	271	54	12.3	0.326	1.6	0.0	0.4	7.18E-07	0.02		

		Highest Predicted Concentration (µg m^{-3})				Non-Cancer Acute		Non-Canc Chr	Cancer			
ID	Receptor	1 hr	6 hr	24 hr	Annual	TR_1	HQ_6	HQ_{24}	ILCR	$\%N_{ex}$ (1hr)	$\%N_{ex}$ (6hr)	$\%N_{ex}$ (24hr)
34	Vauxhall High	50	16	4.0	0.069	0.3	0.0	0.1	1.51E-07			
35	Windward Road Primary & Junior High	12	2	0.6	0.016	0.1	0.0	0.0	3.53E-08			
36	Wolmer's Boys School	4	1	0.2	0.003	0.0	0.0	0.0	7.17E-09			
37	Wolmer's High School for Girls	5	1	0.2	0.004	0.0	0.0	0.0	7.74E-09			
38	Ardenne High	6	1	0.3	0.003	0.0	0.0	0.0	7.39E-09			
39	August Town Primary	0	0	0.0	0.001	0.0	0.0	0.0	2.44E-09			
40	Balmagie Primary	61	12	2.7	0.037	0.4	0.0	0.1	8.20E-08			
41	Bito All Age and Infant	1	0	0.0	0.000	0.0	0.0	0.0	7.26E-10			
42	Calabar High	2	1	0.1	0.003	0.0	0.0	0.0	6.38E-09			
43	Campion College	4	1	0.2	0.002	0.0	0.0	0.0	4.75E-09			
44	Charlie Smith High	17	3	0.7	0.014	0.1	0.0	0.0	3.07E-08			
45	Cockburn Gardens Primary & Junior High	21	5	1.2	0.034	0.1	0.0	0.0	7.53E-08			
46	Constant Spring Primary & Junior High	0	0	0.0	0.001	0.0	0.0	0.0	2.46E-09			
47	Constitution Hill All Age	0	0	0.0	0.000	0.0	0.0	0.0	7.26E-10			
48	Content Gap All Age	0	0	0.0	0.000	0.0	0.0	0.0	4.40E-10			
49	Craighton All Age	5	1	0.2	0.001	0.0	0.0	0.0	1.96E-09			
50	Dallas Primary & Junior High	0	0	0.0	0.000	0.0	0.0	0.0	7.26E-10			
51	Donald Quarrie High	28	6	1.6	0.042	0.2	0.0	0.1	9.31E-08			
52	Drews Avenue Primary and Infant	14	2	0.9	0.019	0.1	0.0	0.0	4.08E-08			
53	Duhaney Park Primary	32	6	1.6	0.027	0.2	0.0	0.1	6.00E-08			
54	Dupont Primary and Infant	46	9	2.0	0.051	0.3	0.0	0.1	1.11E-07			
55	Edith Dalton James High	27	5	1.6	0.024	0.2	0.0	0.1	5.17E-08			
56	Edna Manley College of the Visual and Performing Arts	2	0	0.1	0.003	0.0	0.0	0.0	6.53E-09			
57	Excelsior Community College	3	0	0.1	0.002	0.0	0.0	0.0	5.46E-09			
58	Excelsior High	3	0	0.1	0.002	0.0	0.0	0.0	5.46E-09			
59	Friendship Brook All Age	0	0	0.0	0.001	0.0	0.0	0.0	1.45E-09			
60	Gaynstead High	2	0	0.1	0.003	0.0	0.0	0.0	6.18E-09			
61	George Headley Primary	24	5	1.5	0.019	0.1	0.0	0.0	4.16E-08			
62	Gordon Town All Age	0	0	0.0	0.000	0.0	0.0	0.0	6.82E-10			
63	Greenwich All Age	74	12	3.2	0.059	0.4	0.0	0.1	1.31E-07			
64	Grove Primary	1	0	0.0	0.000	0.0	0.0	0.0	1.06E-09			
65	Haile Selassie High	25	5	1.1	0.037	0.1	0.0	0.0	8.22E-08			

		Highest Predicted Concentration (µg m^{-3})				Non-Cancer Acute		Non-Canc Chr	Cancer			
ID	Receptor	1 hr	6 hr	24 hr	Annual	TR_1	HQ_6	HQ_{24}	ILCR	$\%N_{ex}$ (1hr)	$\%N_{ex}$ (6hr)	$\%N_{ex}$ (24hr)
66	Harbour View Primary	11	2	0.5	0.015	0.1	0.0	0.0	3.38E-08			
67	Holy Childhood High	4	1	0.2	0.004	0.0	0.0	0.0	9.24E-09			
68	Hope Valley Experimental Primary & Infant	1	0	0.0	0.001	0.0	0.0	0.0	1.89E-09			
69	Immaculate Conception High	1	0	0.0	0.001	0.0	0.0	0.0	2.66E-09			
70	Iris Gelley Primary	13	3	0.7	0.012	0.1	0.0	0.0	2.67E-08			
71	Jack's Hill All Age	0	0	0.0	0.000	0.0	0.0	0.0	9.68E-10			
72	Jamaica College	1	0	0.0	0.001	0.0	0.0	0.0	1.80E-09			
73	Jones Town Primary	17	3	1.0	0.014	0.1	0.0	0.0	3.12E-08			
74	Maxfield Park Primary	6	1	0.3	0.006	0.0	0.0	0.0	1.42E-08			
75	Meadowbrook High	1	0	0.1	0.002	0.0	0.0	0.0	3.70E-09			
76	Melrose Primary & Junior High	11	2	0.5	0.008	0.1	0.0	0.0	1.71E-08			
77	Merl Grove High	1	0	0.1	0.002	0.0	0.0	0.0	5.35E-09			
78	Mico Practising Primary & Junior High	3	1	0.1	0.003	0.0	0.0	0.0	7.15E-09			
79	Mico Teachers' College	3	1	0.1	0.003	0.0	0.0	0.0	7.15E-09			
80	Mona Heights Primary	1	0	0.0	0.001	0.0	0.0	0.0	1.43E-09			
81	Mona High	2	0	0.1	0.001	0.0	0.0	0.0	2.09E-09			
82	Mount Fletcher Primary	0	0	0.0	0.000	0.0	0.0	0.0	4.62E-10			
83	Papine High	1	0	0.0	0.001	0.0	0.0	0.0	1.23E-09			
84	Pembroke Hall High	4	1	0.2	0.005	0.0	0.0	0.0	1.15E-08			
85	Priory High	2	0	0.1	0.003	0.0	0.0	0.0	5.74E-09			
86	Red Hills All Age	2	0	0.1	0.001	0.0	0.0	0.0	2.84E-09			
87	Richmond Park Primary	9	1	0.4	0.007	0.1	0.0	0.0	1.45E-08			
88	Rousseau Primary	8	1	0.3	0.006	0.0	0.0	0.0	1.28E-08			
89	Shortwood Teachers' College	1	0	0.0	0.001	0.0	0.0	0.0	2.51E-09			
90	St. Andrew High	3	0	0.1	0.004	0.0	0.0	0.0	8.14E-09			
91	St. Andrew Technical High	99	17	4.6	0.126	0.6	0.0	0.2	2.77E-07			
92	St. Francis Primary & Infant School	3	0	0.1	0.003	0.0	0.0	0.0	5.61E-09			
93	St. Hugh's High	6	1	0.3	0.003	0.0	0.0	0.0	6.82E-09			
94	St. Hugh's Prep	2	0	0.1	0.003	0.0	0.0	0.0	5.83E-09			
95	St. Jude's Primary	4	1	0.3	0.006	0.0	0.0	0.0	1.42E-08			
96	St. Richard's Primary	1	0	0.0	0.002	0.0	0.0	0.0	4.27E-09			
97	Tarrant High	2	0	0.1	0.003	0.0	0.0	0.0	7.13E-09			
98	The Queens School	1	0	0.1	0.002	0.0	0.0	0.0	4.14E-09			

		Highest Predicted Concentration (µg m^{-3})				Non-Cancer Acute		Non-Canc Chr	Cancer			
ID	Receptor	1 hr	6 hr	24 hr	Annual	TR_1	HQ_6	HQ_{24}	ILCR	$\%N_{ex}$ (1hr)	$\%N_{ex}$ (6hr)	$\%N_{ex}$ (24hr)
99	Trench Town High	17	3	0.7	0.014	0.1	0.0	0.0	3.16E-08			
100	Trench Town Primary	27	4	1.1	0.024	0.2	0.0	0.0	5.18E-08			
101	University of Technology	0	0	0.0	0.000	0.0	0.0	0.0	1.06E-09			
102	University of the West Indies	1	0	0.0	0.001	0.0	0.0	0.0	1.52E-09			
103	Whitfield All Age	19	3	0.8	0.021	0.1	0.0	0.0	4.54E-08			
104	Bridgeport High	4	1	0.2	0.006	0.0	0.0	0.0	1.24E-08			
105	Bridgeport Primary	5	1	0.3	0.005	0.0	0.0	0.0	1.19E-08			
106	Cumberland High	3	0	0.1	0.005	0.0	0.0	0.0	1.12E-08			
107	Edgewater	5	1	0.3	0.005	0.0	0.0	0.0	1.20E-08			
108	Greater Portmore High	3	1	0.1	0.004	0.0	0.0	0.0	8.62E-09			
109	Gregory Park Primary	31	6	1.4	0.029	0.2	0.0	0.0	6.40E-08			
110	Independence City Primary	5	1	0.2	0.006	0.0	0.0	0.0	1.31E-08			
111	Naggo Head Infant/Primary	4	1	0.2	0.005	0.0	0.0	0.0	1.09E-08			
112	Port Henderson Primary	4	1	0.2	0.004	0.0	0.0	0.0	9.06E-09			
113	Portsmouth Primary	6	1	0.3	0.008	0.0	0.0	0.0	1.76E-08			
114	Scarborough Primary	3	0	0.1	0.005	0.0	0.0	0.0	1.14E-08			
115	Waterford High	13	3	0.6	0.010	0.1	0.0	0.0	2.20E-08			
116	Waterford Infant	35	7	1.6	0.025	0.2	0.0	0.1	5.58E-08			
117	Waterford Primary	35	7	1.6	0.025	0.2	0.0	0.1	5.58E-08			
118	Andrews Memorial Hospital	3	1	0.1	0.003	0.0	0.0	0.0	7.37E-09			
119	Bellevue Hospital	43	9	2.2	0.045	0.3	0.0	0.1	9.92E-08			
120	Bustamante Children’s Hospital	4	1	0.2	0.003	0.0	0.0	0.0	7.11E-09			
121	Hope Institute	1	0	0.0	0.001	0.0	0.0	0.0	1.76E-09			
122	Kingston Public Hospital	86	18	5.2	0.077	0.5	0.0	0.2	1.69E-07			
123	Medical Associates	2	0	0.1	0.004	0.0	0.0	0.0	8.93E-09			
124	National Chest Hospital	3	1	0.1	0.001	0.0	0.0	0.0	2.71E-09			
125	Nuttall Memorial Hospital	5	1	0.3	0.004	0.0	0.0	0.0	8.60E-09			
126	Sir John Golding Rehab Centre	0	0	0.0	0.001	0.0	0.0	0.0	1.74E-09			
127	St. Josephs	8	1	0.3	0.005	0.0	0.0	0.0	1.15E-08			
128	UHWI	0	0	0.0	0.001	0.0	0.0	0.0	1.25E-09			
129	Victoria Jubilee Hospital (VJH)	40	7	1.8	0.031	0.2	0.0	0.1	6.76E-08			
130	NEPA Mon Station	6	1	0.3	0.005	0.0	0.0	0.0	1.01E-08			
131	NW1	902	180	43.2	1.48	5.3	0.1	1.4	3.26E-06	0.13	0.03	0.01
132	NW2	491	98	23.4	0.715	2.9	0.1	0.8	1.57E-06	0.05	0.01	

		Highest Predicted Concentration (µg m^{-3})				Non-Cancer Acute		Non-Canc Chr	Cancer			
ID	Receptor	1 hr	6 hr	24 hr	Annual	TR_1	HQ_6	HQ_{24}	ILCR	%N_{ex} (1hr)	%N_{ex} (6hr)	%N_{ex} (24hr)
133	NW3	182	41	10.2	0.348	1.1	0.0	0.3	7.65E-07	0.02	0.00	
140	LR	735	316	86.3	6.53	4.3	0.2	2.9	1.44E-05	0.53	0.13	0.10
141	BH	214	46	14.8	0.791	1.3	0.0	0.5	1.74E-06	0.02	0.00	
143	Garmex Monitoring station	1738	348	91.5	2.54	10.2	0.3	3.0	5.58E-06	0.49	0.07	0.09
144	Nearest residence NW	512	91	37.1	1.25	3.0	0.1	1.2	2.75E-06	0.16	0.03	0.01
145	Nearest residence NE	141	28	6.41	0.141	0.8	0.0	0.2	3.11E-07	0.05		

9.5.5 CANCER RISKS

The relationship between the exposure level and the lifetime probability of contracting cancer due to exposure to a carcinogenic compound is expressed by a dose-response relationship. It is generally expressed as a unit risk estimate (URE) [also called the slope factor] which is an upper bound estimate of an individual's probability of contracting cancer over a lifetime of exposure to a concentration of one microgram of the pollutant per cubic meter of air (1 µg m^{-3}). The risks due to exposures to concentrations other than 1 µg m^{-3} are calculated by multiplying the actual concentration to which someone is exposed by the URE or slope factor. The cancer risks from exposure to benzene in air were calculated as the product of the predicted concentrations and the slope factor TRV, and are defined as the incremental lifetime cancer risk (ILCR).

The ILCR was calculated as follows:

$$ILCR = Exp \times SlopeFactor$$

Regulatory agencies have agreed that cancer risk levels of one-in-100,000 (or 1 x 10^{-5}) are essentially negligible, as stated by Health Canada (2004). US EPA has typically used a range (e.g., 10^{-4} to 10^{-6}) for specifying the level for acceptable risk. Exposures which are calculated to cause more than 1 in 10,000 excess cancers are considered to be of concern and may require action to reduce the exposure and resulting risk. The level or range selected depends on a number of factors.

In Ontario, the health risk for carcinogens is normally expressed as a "probability of occurrence". The Ontario Ministry of the Environment (MOE) air standards objective for carcinogens is to set the standard at an incremental risk of 1 in a million (or 10^{-6}) (MOE, 2005). In addition, the MOE generally sets an Upper Risk Threshold at a risk level of 10^{-4} for carcinogens. The concentrations corresponding to the upper risk thresholds are compound specific and are generally 10 times higher than the standard for non-carcinogens and 100 times higher than the standard for carcinogens. When measured or modelled concentrations result in incremental risks between 10^{-6} and 10^{-4} the basis for action takes into account the magnitude (concentration) and the frequency (e.g., the percentage of time in a year that concentrations above the standard occurs).

Six of the 145 receptors – namely the VOC or TSP monitoring stations (LD, NW1, NW2, GRMX, and BH) as well as at the nearest residence to the northwest (NRNW) had incremental lifetime cancer risks (ILCR) that were greater than 1 in 1,000,000: the ILCR values at the remaining 123 non-occupational receptors (i.e., excluding those within Petrojam's property) are less than 1 in 1,00,000 and hence the exposures at these receptors are considered negligible. At 1 x 10^{-5} (1-in-100,000), Health Canada considers the risk to be essentially negligible. Five receptors NW1, NW2 and BH have incremental cancer risks between 10^{-5} and 10^{-6}. Only at the loading rack was the incremental lifetime cancer risk greater than 10^{-5}.

9.5.6 Other Considerations

The frequencies with which exceedances of the 1h and 24 h limits occur at the five receptors range from 0.05% of the time to 2.0% of the time. This low frequency of occurrence would be likely to require much less urgent action in Ontario for example especially if the frequencies were based on measured values.

It is prudent to err on the side of caution and we recommend that the risks due to benzene exposure by the existing refinery should be examined further at receptors in the vicinities of the nearest residences (NRNW, NRNE and NRE), the loading rack (LR) and also at the NW1 and NW2 stations. The first step in such examination is to conduct additional ambient monitoring for benzene. In making the recommendation we are discounting a) the conservative (high) emission rates used in the model, b) the likelihood that the model over predicts, c) the loading rack site should be treated in an occupational exposure context and d) the conservative nature of the unit cancer risk factor.

It is however concluded that the upgrade will not pose any additional risks.

9.5.7 SUMMARY AND CONCLUSIONS

The health risk assessment identified benzene as the compound of concern based on ambient measurement of TSP, speciated VOCs as well as SO_2 and NO_2. Although model predictions suggest that ambient air quality standards could be exceeded, the measured SO_2 concentrations suggest otherwise. The TSP and SO_2 concentrations that were measured in the vicinity of the Petrojam site during the EIA are well below the applicable air quality standards. In view of the limited ambient SO_2 measurements and the model predictions which took into consideration the emissions from nearby JPS Hunts Bay electricity generating station, an ongoing joint (between Petrojam and JPS) monitoring program to measure SO_2 (as well as NO_2 and PM_{10}) is being undertaken. The monitoring program together with additional modelling will definitively assess the impacts due to SO_2 emissions.

Although the upgrade will result in an increase of ~9 g/s (243 tonne/y) of total particulate emissions there will be no change in the highest predicted TSP concentration. [This is because the new sources after the upgrade have taller stacks and the highest predicted concentrations from these sources occur further downwind and have lower maximum concentrations.] Because of this there will be no incremental risk from particulate emissions.

The VOC monitoring undertaken during the EIA entailed measurement of 18 compounds consisting of two chlorinated compounds that are found in consumer products or used in commercial/industrial products or applications, two compounds emitted from vegetation or used in consumer products and hydrocarbons associated with gasoline and petroleum refining . When daily average measurements of these compounds were compared with standards or limits established by various jurisdictions, benzene was the only compound that appeared to exceed the limit. More detailed examination of the monitoring data indicated that there was a single day on which the limit for benzene appeared to have been exceeded and the data (for benzene and the compounds associated most strongly with gasoline) suggested that the samples were contaminated on that day.

In spite of the above benzene was assumed to be a compound of concern. Examination of the sources of benzene emissions indicate that the loading of gasoline into trucks at the loading rack is by far the main source of benzene emissions. Other sources are from storage tanks (the second largest source) and some point sources (those that burn fuel oil or pipestill bottoms which emit relatively negligible amounts of benzene).

The upgrade will not change the total amount of gasoline that is loaded at the loading rack – since the increased gasoline production by the upgraded refinery will result in a similar reduction in imported gasoline. Hence the upgrade will not result in an increase in benzene emissions from the loading rack or storage tanks. Because of this it was not necessary to model benzene emissions after the upgrade in the health risk assessment.

Since benzene is classified as a Group 1 carcinogen (carcinogenic to humans) by the International Agency for Research on Cancer and a Group A carcinogen (human carcinogen) by the USEPA. As such, benzene was assessed for both non-carcinogenic and carcinogenic effects in the risk assessment.

Comparisons between the measurements and the model predictions show that the model predictions are between 1 and 4 times greater than the highest measurements (when data for September 8 are excluded). Comparison of the model predictions with a 1 hr average screening level also suggested further examination of the predictions by comparisons with toxic reference values.

The health risks associated with benzene emissions from the refinery were estimated by comparing the exposure rates predicted by the model with established toxicity reference values (TRVs). These TRVs are provided as rates of exposure to which the receptor can be exposed without adverse human health effects. Risks are estimated by directly comparing the project-specific rate of exposure to the TRV. TRVs are established by regulatory agencies (e.g., USEPA, California Air Resources Board, Health Canada or the Ontario Ministry of the Environment) and are based on animal toxicity tests or human epidemiological studies.

Generally, the RfCs provided by IRIS are estimates (with uncertainty spanning perhaps an order of magnitude) of daily continuous 24-hour exposure of the human population, including sensitive subpopulations, that is unlikely to cause adverse effects during a lifetime. Since IRIS and ARB provided TRV values, the lower (more stringent) value was used to evaluate the hazard quotient. Acute effects were assessed by comparing the highest predicted 6 hr benzene concentration to the California Air Resources Board acute reference value (1300 µg m^{-3} for a 6 hr averaging period).

In order to account for exposure pathways other than by air, 20% of the TRV is allocated for each pathway. Hence it is assumed that people are exposed to contaminants in soil (0.2), groundwater (0.2), air (0.2), food (0.2) and consumer products (0.2) for a total of 100% or 1. An apportionment factor of 0.6 for benzene was used because it may be present in air, soil and groundwater.

The model predictions were made at a number of sensitive receptors as well as at the stations at which benzene (and other VOCs) were measured. Note that one of the monitoring stations – called LD (for the loading rack) was actually on Petrojam's property and as such it should be treated as an occupational exposure station.

At the special receptors, health risks associated with acute exposure to benzene remained significantly below the target HQ of 0.6 at all receptors. For chronic exposure – based on the highest predicted daily average benzene concentration, five receptors NW1, NW2, LR, GRMX and the nearest residence to the northwest hazard quotients greater than 0.6.

Six of the 138 receptors that were located off the Petrojam property – namely the VOC monitoring stations (NW1, NW2, LR, BH, GRMX and the nearest residence to the northwest) had incremental lifetime cancer risks (ILCR) that were greater than 1 in 1,000,000: the ILCR values at the remaining 132 receptors are less than 1 in 1,000,000 and hence the exposures at these receptors are considered negligible.

At an incremental risk less than 1×10^{-5} (1-in-100,000), Health Canada considers the risk to be essentially negligible. Only at the loading rack was the incremental lifetime cancer risk greater than 10^{-5}.

In spite of the conservative nature of the model predictions and in specifying TRVs, it is prudent to err on the side of caution and to conclude that the risks due to benzene exposure by the existing refinery should be examined further. Since the risk estimates were based on predictions the first step in the assessment must be ambient monitoring for benzene.

It is however concluded that the upgrade would not pose any additional risks

9.6 DRAFT MONITORING PLAN OUTLINE

9.6.1 Background

The Management of the Petrojam Limited proposes to upgrade the Petrojam Refinery. The National Environment and Planning Agency (NEPA) has approved this operation with certain conditions, one of which is the requirement that operations be monitored to their satisfaction.

The Refinery Upgrade Project is approved by:

BCA Licence #......., and **NRCA Permit Nos……..**

This monitoring Plan details the Monitoring Programme required by **BCA Licence……….**, and **NRCA Permit Nos.** The programme includes periodic environmental monitoring during construction and ongoing monitoring after the upgrade and the submission of reports at agreed intervals.

9.6.2 Scope of Study and Methodology

The monitoring programme is designed to verify that the requirements of the Licences and Permits granted by the NEPA are met. This monitoring program covers the period during construction and ongoing operation of the refinery after the upgrade. The monitoring will evaluate and help to ensure the effectiveness of mitigation of impacts during the construction period and after the upgrade. It will also verify operation of pollution control equipment specifically the wastewater treatment plant and the sulphur recovery unit.

The monitoring program will include the following:

Ambient air quality (to commence as soon as possible and will therefore include measurements during construction and after the upgrade)

a) Continuous monitoring of SO_2, NO, NO_2 and NOx and also meteorological parameters (wind speed, wind direction and temperature) at three stations in a joint program with Jamaica Public Service Company Limited (JPS). NEPA has approved the sites for these stations, namely the Boat House (BH), Garmex/HEART Academy site (GRMX) and a site in Newport West (NW2) as shown in Figure x.
b) Monitoring of PM_{10} at the three stations in a) above. Monitoring will take place every sixth day and will follow the North American Schedule for TSP/PM_{10} monitoring
c) Monitoring of TSP during the upgrade at two locations (to be determined based on construction activity) on Petrojam's property. Monitoring will be for TSP rather than PM_{10} because of the nature of emissions (coarser particles than from combustion sources) from construction activity.
d) Continuous monitoring of total reduced sulphur (TSR) at one of the three stations (NW1) in a) above. Monitoring will commence as soon as possible

e) Monitoring volatile organic compounds (VOCs) at five stations every six days over as three month period
   - Nearest residences to the northwest, north east and east
   - Stations BH, GRMX, NW1 and a site near the loading rack (LR)
   - The VOCs will be monitored using passive sampling (3M OVM550 badges) and exposure will be over 48 hours
   - The individual VOCs should include the following:
     - Benzene
     - p-Xylene
     - Tetrachloroethylene
     - Trichloroethylene
     - (m+p)-Xylenes
     - 1,3-Diethylbenzene
     - 2,2,4-Ttrimethylpentane
     - 2,2-Dimethylbutane
     - 2-Methylheptane
     - 2-Methylhexane
     - α -Pinene
     - Decane
     - d-Limonene
     - Heptane
     - n-pentane
     - Octane
     - Toluene
     - Ethanol
     - MTBE
     - 1-pentene
     - 2-methyl-2-butene
     - 1-methyl-1-butene
     - 3-methylpentane
     - 2,2-dimethylbutane
     - 2-methylhexane

Occupational Monitoring (continuation of ongoing program)

f) for total hydrocarbons, total reduced sulphur and SO_2 at four locations within the property using Drager tube (grab) sampling (weekly samples)

g) Occupational noise monitoring will be made during construction at three perimeter locations and in the vicinities of pile driving and noisy locations. The locations will be determined based on construction activity.

Source emissions monitoring (to commence after the upgrade)

h) Continuous emissions monitoring of the tail gas stack for H_2S.

Water quality monitoring

i) Monitoring the effluent from the existing waste water treatment plant, from the new wastewater treatment plant (WWTP) once the WWTP is completed and from the storm water drain and the drain from the ethanol plant. Once the upgrade is completed the effluent from the new plant will be monitored instead.
   - The monitoring will entail measurement of the following parameters based on composite 24 hour sampling [except as noted]
     - Flow rate
     - Oil and grease
     - pH
     - Phenols
     - Phosphate as o-$(PO_4)^{3-}$
     - Sulphide
     - Total dissolved solids (TDS)
     - Temperature
     - Total suspended solids (TSS)
     - Chromium
     - Biological oxygen demand over five days (BOD_5) [grab sampling]
     - Chemical oxygen demand (COD)
     - Dissolved oxygen (DO)
     - Total Coliform
     - Faecal Coliform
     - Total Nitrogen

Marine and ecological observations during construction - to observe any changes in the marine water quality and the composition of marine, (benthic, pelagic) species.

j) Marine water quality will be assessed near the outfalls once every three months during construction. The water quality parameters monitored are the same as in i) above except for flow rate and chromium.
k) Monitoring will be carried out more frequently if the results of the first two months suggest that there are potential changes in the marine or ecological parameters.
l) Ecological observations would be conducted every three months during construction. Plankton tows will be used to sample the pelagic marine community and sampling of marine benthos will be made along the same transects used in the EIA.

9.6.3 Output/Reporting

The information from the monitoring program will be used to guide Petrojam regarding the environmental quality and of the efficacy of the mitigation and pollution control measures. Any changes required to enhance the effectiveness of existing mitigation actions would then be recommended. Monitoring reports will be provided to NEPA on a quarterly basis during construction and for the first year after the upgrade. After the first six months of construction, the frequency of reporting will be assessed to determine the need for reducing (or increasing) the frequency.

Monitoring reports will contain the results of all monitoring data and associated information (e.g., unusual operational activity at the refinery, construction activities (during the construction period), photographic records, complaint data, unusual events including pollution incidents) collected or which occurred during the quarter.

The reports will include recommendations for action, if required, for improving environmental quality or streamlining the reporting and monitoring protocols. Data will be presented in both tabular and spatial form on maps prepared for this purpose.

9.7 PROJECT PERSONNEL

The following persons were involved in the study:

Claude Davis, *Ph.D.*	Project Manager, Air Quality, Impact Assessment
Donovan Rose *M.Sc*.	Project Coordinator, Legislative aspects
Peter Gayle *B.Sc.*	Ecology
Paul Carroll *M.Sc*.	Environmental Chemistry, Air Quality, Occupational Health
Allison Richards *M.Sc*.	Socioeconomics
Brian Richardson *M.Sc.*	Hydrogeology
Pierre Diaz *B.Sc.*	Oceanography/Coastal Dynamics
Leslie James *B.Sc.*	Air quality
Michelle McNaught *M.Sc.*	General support
Sub Contractors	Smith Warner International Ltd. (Storm Surge)
	VE Collective (Air Quality)